University of Tasmania

Doctoral Thesis

Idiosyncratic risk assessment in the mortgage market

Author:
María Belén Yanotti

Supervisors:
Dr. Mardi Dungey
Dr. Graeme Wells
Dr. Firmin Doko Tchatoka

A thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

in the

Discipline of Economics and Finance
Tasmanian School of Business and Economics

UNIVERSITY OF TASMANIA

February 2015

Declaration of Authorship

I, María Belén Yanotti, declare that this thesis titled, 'Idiosyncratic risk assessment in the mortgage market' and the work presented in it are my own. I confirm that this work was done wholly or mainly while in candidature for a research degree at this University. Consultation of the published work of others has always been clearly attributed. Where I have quoted from the work of others, the source is always given.

This dissertation consists of seven chapters: an introductory chapter, a literature and market overview chapter, a data description chapter, three main research chapters, and a concluding chapter. I am the single author of Chapters 2 and 3. Chapter 2 has been adapted into a joint contribution with Dr. Judy Yates and will be published in a special issue of the European Network of Housing Research (ENHR). Chapters 4, 5 and 6 are co-authored with my supervisors. Chapters 4 and 5 has been submitted for publication. Most data used in this thesis is confidential.

Earlier versions of Chapter 5 were presented at conferences at the Housing Market Workshop (University of Tasmania) in October 2012, at the Australian Mortgage Conference (Sydney) in February 2013; at the ESAM meeting (University of Sydney) in July 2013; at a EMF-ENHR Housing Finance Seminar (EMF, Brussels) in September 2013; at the IFABS Conference (ISCTE - University Institute of Lisbon) in June 2014; at the ESAM meeting (University of Tasmania) in July 2014; and at seminars at the University of Tasmania, the National University of Ireland - Maynooth in September 2012, the National University of Tucumán in November 2012, the Reserve Bank of Australia in November 2012, the University of Groningen in September 2013, and the University of Guelph in October 2013.

This work has not previously been submitted in part or as a whole for any degree or any other qualification at this University or any other institution. This thesis may be made available for loan. This thesis may be made available for loan and limited copying and communication in accordance with the *Copyright Act* 1968.

Signed: _____

Date: _____

Abstract

This thesis investigates the role of borrower characteristics in revealing risk assessment in the mortgage market. Two innovations make important contributions to the international literature. First, the thesis exploits a unique, detailed mortgage application database which provides a means by which to investigate the role of individual characteristic and personal circumstances in the variety of mortgage contracts found in the market. Second, it takes advantage of the distinctive characteristics of Australian financial markets to analyze contract choice in an environment where, due to the relative underdevelopment of a mortgage securitisation market and absence of government guarantees, the risks of the mortgage contract are spread mainly between the originator (the bank) and the mortgagee (the household).

As a result of the impact and spread of the global financial crisis of 2008-09, governments and regulators are focusing their attention on macroprudential policy and systemic risk. Results presented in this thesis demonstrate that underpinning these macroeconomic concerns are important issues for the understanding of idiosyncratic mortgage risk. We focus on these micro level problems by studying loan-level owner-occupier mortgage application data. This work reinforces the relevance of assessing and pricing the risk for borrowers and lenders based on the personal characteristics of the individual household. In particular, the thesis investigates the role of borrower characteristics in the determination of: (i) mortgage product choice; (ii) loan-to-value ratios; and (iii) mortgage interest rate.

The thesis brings together three substantive essays which are intended to be published as separate papers, accompanied by two chapters which provide background to the Australian financial sector (and the role of mortgage markets) and details on the micro loan-level application data on which the subsequent empirical work is based. The first essay aims to provide a formal clarification of the association between borrower characteristics and types of mortgages by building typologies of borrowers based on their characteristics and the type of mortgage they take. It introduces the use of Multiple Correspondence Analysis techniques to household finance data. The empirical work finds that young, low-income and low-wealth applicants deviate from the mean borrower, and that households with high income but low wealth are associated with variable- or fixed-rate mortgages, while households with low income but high wealth are associated with home equity loans and discounted variable-rate mortgages. However, borrowers remain heterogenous within mortgage types. Fixed-rate mortgages are taken by young, constrained families, settled families and mobile first-time buyers. Discounted variable-rate

mortgages are taken by young (female) households, settled families and mobile first-time buyers.

The second essay considers the empirical evidence on mortgage product choice with the inclusion of a full range of variables representing mortgage costs, market conditions and borrower characteristics, consistent with models proposed in the theoretical literature. A discrete choice model is used to predict the marginal effect of borrower characteristics on the probability of choosing a particular mortgage product. Moreover, it explores the way mortgage choice effects are affected by loan-to-value ratio incentives given to banks and imposed by the Australian regulatory body - in accordance with the Basel capital requirements. It reveals a relationship between the prudential regulatory structures and the mortgage choice at an individual-level. It finds that, contrary to popular wisdom, the Basel capital adequacy rules play a 'sorting' role in terms of the types of loan contracts that emerge from the interaction between banks and borrowers. Although mortgage choice is mainly determined by the relative cost of the mortgage and by a broad range of borrower characteristics - which reveal life-cycle stage, income and wealth constraints and uncertainty, risk-aversion, financial experience, and mobility expectations - these borrower characteristics play different roles for different loan-to-value ratio levels.

The third essay addresses possible endogeneity and bias selection in estimating mortgage choice. Endogeneity is addressed by predicting the loan-to-value ratio and instrumenting the value of the property under the mortgage contract. Selection bias, which arises from observing only the revealed preference of the borrower and not the alternatives in the choice, is corrected by estimating the reduced form of the interest rate associated with the mortgage. This chapter focuses on the effect borrower characteristics have on interest rate and loan-to-value ratio determination. It finds that the value of the property at the time of application is not statistically significant in determining the loan-to-value ratio the bank offers to the borrower; however house price inflation and expectations determine the loan-to-value ratio. Moreover, income and wealth levels are strong factors determining both loan-to-value ratios and individual interest rates. Importantly, borrower characteristics play the role predicted by theory in defining price and terms of the mortgage at the individual level. This finding is necessary, but not sufficient, for market efficiency.

Acknowledgements

I would like to thank my supervisors, Professor Mardi Dungey, Associate Professor Graeme Wells and Associate Professor Firmin Doko Tchatoka, for their guidance, support, inspiration and encouragement over the past years. I extend this gratitude to the members of the Tasmanian School of Economics and Finance (TSBE) at the University of Tasmania (UTAS) for collegiate assistance and support during my candidature.

My research has benefited from suggestions and comments by many academics, including Associate Professor Judith Yates, Dr. Veronica Cacdac Warnock, Prof. Frank Warnock, Associate Professor J. P. A. M. Jacobs, and Professor John Y. Campbell. I am grateful for the helpful comments and suggestions from the thesis examiners. I would also like to thank participants at the Housing Market Workshop (University of Tasmania) 2013; at the Australian Mortgage Conference 2013; at the ESAM (University of Sydney) 2013; at EMF-ENHR Housing Finance Seminar (European Mortgage Federation, Brussels) 2013; at the IFABS Conference (ISCTE - University Institute of Lisbon) 2014; at the ESAM/ACE (University of Tasmania) 2014; and at seminars at the University of Tasmania, the National University of Ireland - Maynooth in September 2012, the National University of Tucumán in November 2012, the Reserve Bank of Australia in November 2012, the University of Groningen in September 2013, and University of Guelph in October 2013.

I am very grateful for scholarship and grant support. I acknowledge funding support from Australian Research Council grant DP120100842, and from UTAS International Postgraduate Research Scholarship and the Australian Postgraduate Award. I acknowledge research assistance from Sharon Raymond.

I would also like to thank my lecturers and educators and administrative staff at Departamento de Economía, Facultad de Ciencias Económicas, Universidad Nacional de Tucumán, Argentina, for their inspiration and dedication. Special thanks to Dr. Victor Jorge Elías, Dra. Ana María Cerro and Osvaldo Meloni.

Finally, to my parents and siblings 'gracias por educarme y darme su apoyo incondicional'. To my husband, Marcus Salonen, for your love, companionship and support, especially in accomplishing my goals. To my relatives and friends, thank you for the encouragement and support.

Contents

List of Figures

List of Tables

Abbreviations

ABS	**A**ustralian **B**ureau of **S**tatistics
ACT	**A**ustralian **C**apital **T**erritory
ADIs	**A**uthorised **D**eposit-taking **I**nstitutions
AMP	**A**lternative **M**ortgage **P**roduct
ANZ	**A**ustralian **N**ew **Z**ealand Banking Group Limited
AOFM	**A**ustralian **O**ffice of **F**inancial **M**anagement
APRA	**A**ustralian **P**rudential **R**egulation **A**uthority
ARM	**A**djustable-**R**ate **M**ortgage
ASIC	**A**ustralian **S**ecurities and **I**nvestment **C**ommission
CBA	**C**ommonwealth **B**ank of **A**ustralia
CDS	**C**redit **D**efault **S**wap
CGS	**C**ommonwealth **G**overnment **S**ecurities
CM	**C**omplex **M**ortgage
CPI	**C**onsumer **P**rice **I**ndex
CRAA	**C**redit **R**eference **A**ssociation of **A**ustralia
DSR	**D**ebt **S**ervicing **R**atio
FCS	**F**inancial **C**laims **S**cheme
FHOG	**F**irst **H**ome **O**wner **G**rant
FHB	**F**irst-time **H**ome **B**uyer
FRM	**F**ixed **R**ate **M**ortgage
GFC	**G**lobal **F**inancial **C**risis
GSE	**G**overnment **S**ponsored **E**nterprises
HE	**H**ome **E**quity Loans
HM	'**H**oneymoon' **M**ortgage (discounted variable-rate mortgage)
ICA	**I**nsurance **C**ouncil of **A**ustralia

IMF	**I**nternational **M**onetary **F**und
LCR	**L**iquidity **C**overage **R**atio
LMI	**L**oan **M**ortgage **I**nsurance
LTV	**L**oan-to-**V**alue **R**atio
MBS	**M**ortgage-**B**acked **S**ecurities
MCA	**M**ultiple **C**orrespondence **A**nalysis
NAB	**N**ational **A**ustralia **B**ank
NSW	**N**ew **S**outh **W**ales
NT	**N**orthern **T**erritory
OIS	**O**vernight **I**ndex **S**wap
PCA	**P**rincipal **C**omponent **A**nalysis
PTIR	**P**ayment-**T**o-**I**ncome **R**atio
QLD	**Q**ueensland
RBA	**R**eserve **B**ank of **A**ustralia
RIPL	**R**esidential **I**nvestment **P**roperty **L**oan
RMBS	**R**esidential **M**ortgage-**B**acked **S**ecurities
SA	**S**outh **A**ustralia
SFRM	**S**hort-term **F**ixed-**R**ate **M**ortgage
TAS	**T**asmania
UMI	**U**ncommitted **M**onthly **I**ncome
VIC	**V**ictoria
VRM	**V**ariable-**R**ate **M**ortgage
WBC	**W**estpac **B**ank **C**orporation

Chapter 1

Introduction

Mortgages are complex contracts committing the parties involved to a long-term transaction agreement, and financing a good with both consumption and investment characteristics. Property investment has been stimulated by the growth in asset prices during the last quarter of the century, and modern mortgage instruments allow some level of consumption smoothing for the borrower over the life cycle of a mortgage contract.[1] The uncertainties associated with long-term loans generate a series of risks for all parties involved in the contract, and the mortgage products offered may hedge some of those risks for some parties.[2] In a world of certainty, the value of a mortgage from the lender's perspective is the expected present value of its future stream of benefits, discounted at an appropriate rate. However, mortgage design and pricing is more challenging in a stochastic economic environment with incomplete and asymmetric information, potential moral hazard and adverse selection.[3] The future value of the mortgage cannot be known with certainty and, for this reason, preferences enter into valuations through differing risk attitudes and business strategies.

[1] Elsinga [84] notes that modern mortgage instruments allow borrowers to extract the equity of their home earlier than they typically used to through mortgage equity withdrawal contracts, for example.

[2] The parties in a mortgage contract are the borrower(s) and lender, but other parties are also involved in this transaction such as mortgage insurance providers (in some jurisdictions government provided), investors in residential mortgage backed securities (RMBS) in the securitization market, and, potentially, mortgage brokers or intermediaries – such as lawyers and real estate agents.

[3] For example, Dunn and Spatt [79] and Stanton and Wallace [174] argue that lenders may know the distribution of borrowers' types and design mortgage contracts accordingly, however they can not observe the borrower individual type, which leads to potential adverse selection. Spiegel and Strange [173] argue that borrowers with high mortgage repayments have less incentive to care and maintain the house under the contract mortgage, which in turn affect the expected housing excess returns leading to adverse selection.

This thesis focuses on understanding the role of borrower characteristics and individual circumstances – which reveal borrowers' preferences and risk attitudes – in the mortgage product selection and pricing. In the next chapter I present an overview of the Australian market to contextualize the background of the database used throughout this study. The Australian mortgage market has many similarities with other mortgage markets around the world. The predominant owner-occupier home loans offered in Australia are variable-rate mortgages (VRMs), short-term fixed-rate mortgages (SFRMs), discounted variable-rate or 'honeymoon' mortgages (HMs), and home equity loans (HEs). In the third chapter I describe the rich proprietary database on owner-occupier mortgage applications used in this thesis. In the fourth chapter I explore borrower characteristics in a non-parametric manner by building borrower typologies based on the type of mortgage product selected, through the application of multiple correspondence analysis (MCA) and cluster analysis. Initial results show that households with high income but low wealth are more likely to take VRMs and SFRMs, while households with high wealth but low income prefer products such as 'honeymoon' mortgages (HMs) and home equity loans (HEs). I construct six distinctive borrower typologies in the Australian market. In subsequent chapters, I predict the conditional probability of observing a borrowers' application for a VRM and the determinants of that outcome, with particular focus on borrowers' individual characteristics. I find strong evidence of multiple borrower characteristics playing a role in the mortgage product choice. In addition, I investigate the role of regulatory capital requirements in an environment where banks hold mortgage risk on their balance sheet and find that the capital requirement discounts based on loan-to-valuation ratios (LTVs) divide otherwise similar borrowers between VRM and other product choices. These findings are very timely given the current international discussion on the adoption (and assessment) of maximum LTV regulations and capital requirement incentives. The last chapter disentangles the impact of borrower characteristics on mortgage product choice into a direct effect on mortgage product choice and an indirect effect through mortgage price determination. It addresses the endogeneity between interest rate and LTV determination.

The recent international developments that resulted in a global financial crisis provide evidence of the consequences misunderstanding and mis-measurement of financial risks have for the real economy. Governments and regulators are currently focusing their attention on assessing those risks. Although academic debate concentrates on systemic

risk and the interactions between financial players in spreading the crisis, the idiosyncratic risks in financial tools – such as mortgage products – become paramount not only in triggering a crisis but also in its impact on the real economy, as was recently experienced. Mortgages and mortgage-backed securities were at the center stage of the recent global financial crisis. Many governments and banking regulators around the world have taken, or are in the process of taking, actions to reduce the vulnerability of the banking, mortgage and securitization markets.[4] The relevance of understanding the individual risk-sharing mechanism in a mortgage contract is then timely.

Borrowers face diverse risks when committing to a long-term contract such as a mortgage; see Campbell and Cocco [43].[5] Employment probability and real income growth and volatility lead to income risk, which translates into the possibility of not being able to meet scheduled mortgage repayments or, alternatively, being able to repay the loan at an earlier date than contracted.[6] Changes in borrower's net wealth and equity lead to wealth risk, which affects the probability of early prepayment or default. The possibility that the borrower will hold the property under the mortgage contract only for a short period relative to the term of the contract is defined as mobility risk, and can be impacted by changes in family size and work mobility. In addition, borrowers face limitations through risk-aversion, low financial literacy, and income and wealth constraints.

From the lender's perspective, mobility risk and positive shocks on wealth or income can be interpreted as prepayment risk. The possibility that borrowers prepay their mortgages ahead of schedule may signify a mismatch between short- and long-term obligations and rollover costs for the lender. Negative shocks on income and wealth are translated into default risk, and eventually recovery risk.

Each risk has a systemic and an idiosyncratic component. Market risks affect borrowers' and lenders' individual risks. Interest rate risk is expected to be correlated with real income risk for the borrower (and in some cases wealth risk), and affects costs of debt funding for the lender; inflation will affect both income and wealth risks; the aggregate

[4]For a review of macroprudential policies in different countries see IMF [117]. For example, Australia has put in place a Financial System Inquiry, is implementing Basel III capital accords, and it is opening a credit liquidity facility (CLF) to meet total liquidity needs. This facility will implement a system of data collection and publication with comprehensive information on securitized mortgages, in order to enhance transparency.

[5]See also Piskorski and Tchistyi [153], Stanton and Wallace [174], and Dunn and Spatt [80].

[6]Considerations such as expenditure patterns and uncommitted or disposable income are relevant here.

unemployment rate may affect income risk and mobility risk. The idiosyncratic component of the borrower's risk is mainly determined by the individual characteristics and circumstances of the borrower. This thesis concentrates on understanding the latter.

Many economic and financial studies consider the risk-sharing structure between borrowers and lenders. Relevant topics on mortgage contracts are: (1) mortgage choice, (2) mortgage price determination, (3) mortgage termination (prepayment and default behavior),[7] and (4) refinancing options. In addition, mortgage contracts are pooled into asset-backed securities and sold in the secondary market. Mortgage-backed security (MBS) valuation, determined by prepayment and default options, is also relevant in the study of mortgages in the securitization market.

A series of papers study the choice of taking a mortgage as a financing method for residential property.[8] However, most of the work on mortgage choice studies mortgage product selection, concentrating traditionally on the choice between fixed-rate mortgages (FRMs) and adjustable-rate mortgages (ARMs); see Campbell and Cocco [43], Baesel and Biger [19], Alm and Follain [7].[9] However, research has expanded to a variety of newer and increasingly popular mortgage products.[10]

Home loan borrowers also consider the loan size, the term of the mortgage,[11] whether to contract a mortgage with the mortgage originator or with an intermediary party (such as mortgage managers and brokers), and whether to take available private or public mortgage insurance. Research on the size of the home loan estimates the joint determination of mortgage debt and the value of the residential property under the mortgage contract; see for example Ling and McGill [139]. Research on loan-to-value ratios (LTV) has become increasingly popular with the emergence of the global financial crisis and the resulting trend towards macroprudential policy.[12]

Lenders asses the design of mortgage products to offer and price them accordingly, with much variability across jurisdictions. A series of studies concentrate on mortgage price

[7]For a review on mortgage default see Quercia and Stegman [156]. See also Zorn and Lea [194].
[8]See for example Haurin et al. [107], Paiella and Pozzolo [150], Ehrmann and Ziegelmeyer [82].
[9]For existing empirical research on mortgage product choice see Brueckner and Follain [34], Dhillon et al. [73], Paiella and Pozzolo [150], Sa-Aadu and Sirmans [162], Coulibaly and Li [54], Vickery [183], and Ehrmann and Ziegelmeyer [82].
[10]See for example Amromin et al. [10], Scanlon et al. [166] and Cocco [50].
[11]See for example Dhillon et al. [74].
[12]See Qi and Yang [155] and Cunha et al. [56]. For macroprudential policy using LTVs see Crowe et al. [55] and Wong et al. [187].

determination; in particular, they predict mortgage interest rates,[13] but also investigate bank fees and points.[14] Part of this literature addresses the impact of GSEs on mortgage rates and mortgage choice.[15] The study of mortgage interest rates and product selection has also included social issues such as racial or gender discrimination in mortgage lending.[16] However, Berkovec et al. [24] and Cavalluzzo and Cavalluzzo [48] argue that it is difficult to separate the effect of risk from that of market power in the formation of interest rates; if market power is present, standard price discrimination can in turn become the explanation for differential treatment, without necessarily reflecting the presence of prejudice.[17] Financial literacy in the mortgage market also plays a critical role.[18]

Mortgage choice has important macroeconomic implications. Mortgages are, in many countries, a channel of monetary policy transmission. The distribution of risk in the economy could have a relationship with the spread and magnitude of a shock; Landier et al. [131]. Debelle [65] argues that a larger stock of household debt increases the sensitivity of the household sector to fluctuations in income, interest rates and house prices, and adds that countries with predominant share of VRMs have displayed higher house price growth and volatility than countries with mainly FRMs.

Finance literature on mortgages generally apply option-based theory to mortgage valuation. The evolution of a mortgage over time is of particular interest for mortgage and insurance providers, and for investors in mortgage-backed securities; see Dunn and McConnell [78]. The option-based approach, however, understates the role of borrower preferences and characteristics; see Kau and Keenan [120].[19] In particular, interest lies on mortgage performance and the prepayment and default options.[20]

[13] See for example Rosenthal and Zorn [159], Ambrose et al. [8] and Gary-Bobo and Larribeau [94].

[14] See for example Kau and Keenan [119] and Yang [190].

[15] See Hendershott and Shilling [110], Hendershott et al. [109], McKenzie [142], Ambrose et al. [9], Passmore et al. [151], and Fuster and Vickery [92].

[16] See for example Munnell et al. [148], Schafer and Ladd [167], and Ladd [129].

[17] See also Yezer et al. [193].

[18] See Gerardi et al. [97], Lusardi [141], and Miles [143].

[19] Kau and Keenan [120] argue that the accomplishment of the option theory is to show that the role of preferences is actually quite limited when applied to derivative assets.

[20] Prepayment can be considered an American-style call option; the borrower has the right to gain the house at any time by paying off the loan. Default can be treated as a European compound put option; the borrower turns over possession of the house in exchange for abandoning payments and such default rationally occurs only when a payment is due and there is not just one payment date but a succession of them (a borrower who does default but instead makes a payment receives the right to default in the future); see Deng, Quigley and Order [71], Kau, Keenan and Smurov [121], and Burkhard and De Giorgi [37].

This thesis concentrates on mortgage product choice and price, with particular focus on the role of borrower characteristics. Although lenders assess borrower preferences and risks through the collection of personal demographic and financial (both soft and hard) information, borrowers have power in choosing and negotiating rates based on their preferences and private information. In an era where technological advancement allows rapid and inexpensive collection and storage of individual information, the impact that borrower characteristics have on mortgage product choice and price become relevant.

The thesis is organized as follows. Chapter 2 presents the background review on the Australian market. Chapter 3 follows by describing the rich bank-generated dataset on mortgage applications. Chapter 4 builds owner-occupier borrower typologies to explore their characteristics further. Chapter 5 predicts conditional probabilities of VRM applications, and its determinants. This chapter contributes in distinguishing the relevant borrower characteristics in mortgage product selection for different LTV levels, as defined by the capital requirement discount incentives to the banking sector. Chapter 6 addresses endogeneity in the mortgage product choice specification, with special focus on mortgage interest rate and LTV determination. In particular, chapters 4-6 have been written as stand-alone papers and may repeat some of the descriptive material. The last chapter presents a conclusion and suggestions for future work.

Chapter 2

The Australian Mortgage Market

2.1 Introduction

During the 1980s, Australia experienced a series of reforms that would transform its economy. From the early 1980s to 1996, financial markets were freed from price controls, entry was liberalized, and the regulatory structure was renovated. By 1996, the transition from discretionary monetary policies to an inflation-targeting regime was complete; see de Brouwer [62].

The first major reform was in December 1983, when the Australian government decided to float the exchange rate and remove most capital controls; since then, the Reserve Bank (RBA) has only intervened in foreign exchange markets to prevent 'disorderly' market behavior. The second step was the process of deregulation and opening capital markets. Interest rate controls on loans were removed in April 1985.[1] Restrictions on the entry of foreign banks were relaxed in the previous year, allowing fifteen new overseas banks to be licensed and participate in the Australian financial market.[2]

By 1988, Australia had the foundations of the modern economic and financial era, characterized by freer trade, deregulated markets, lower tax rates, low inflation, and a more

[1] Controls over interest rates on certificates of deposits and other bank deposits were removed in 1973 and 1980, respectively.

[2] Before 1985, only two foreign institutions operated as authorized banks in Australia in the post-war period. Since 1985, most overseas banks have assumed subsidiary status (rather than a branch structure), which requires capital to be held locally. For more details see 'Box C: Foreign-owned banks in Australia', Reserve Bank of Australia Financial Stability Report, March 2007, http://www.rba.gov.au/publications/fsr/boxes/2007/mar/c.pdf.

market-oriented economy; see Kelly [122]. Deregulation was expected to deliver more effective monetary policy, and increase access to credit and financial innovation.

However, the foundations for a modern and stable financial system were incomplete without a modern regulatory regime. The large losses experienced by several banks in the late 1980s and the beginning of the 1990s highlighted weaknesses in risk management within financial institutions. As a consequence, the 1990s saw the beginning of new arrangements for prudential supervision of these institutions. During the first half of that decade, the RBA conducted targeted, risk-based, on-site bank reviews. The *Wallis Inquiry* in 1996 set the basis for the development of the structure of a prudentially regulated financial system.

The last major reform was the formal adoption of an inflation-targeting regime. After a period of unsatisfactory discretionary monetary policy, the RBA, in agreement with the Federal Treasurer, announced in 1996 it would target a 2-3 percent inflation rate. For more discussion on deregulation in these early stages, and in particular a detailed timeline of the reforms, see de Brouwer [62]. By 1998, with the implementation of inflation targeting and the establishment of a regulatory oversight of risk-taking by banks and other financial institutions, the main features of Australia's modern financial markets were in place.

The rest of this chapter proceeds as follows. Section 2.2 presents a review of the Australian mortgage market during the twenty years prior to the global financial crisis (GFC), with particular focus on the demand for, and supply of, housing credit. Section 2.3 discusses the impact of the GFC on the mortgage market. It first concentrates on relevant policy responses to the global turmoil and then analyzes the demand for, and supply of, mortgages during the crisis period. Section 2.4 provides an overview of mortgage products currently offered in Australia. Section 2.5 presents concluding remarks.

2.2 The Australian mortgage market: 20 years before the GFC

As previously stated, some of the modern features of Australia's financial system were in place by 1988, but the framework for prudential regulation was still underdeveloped.

Deregulation increased the number of financing institutions and was accompanied by new financial products. Greater competition and easier access to funds facilitated rapid growth in the balance sheets of institutions, along with a rapid expansion of credit, particularly for commercial property investment. At the same time commercial property prices were increasing rapidly. However, prudential standards did not keep pace with these market developments, and in 1989, high interest rates and a deceleration of commercial property prices contributed to exposing risky loans. The economy fell into recession between 1990 and 1992, and several financial institutions experienced large losses; see Gizycki and Lowe [98].[3]

This experience uncovered the need for regulatory reform and motivated the *Financial System ('Wallis') Inquiry* in June 1996; see Harper [106]. The *Wallis Inquiry* set the basis for a tightening of regulatory oversight of risk-taking financial institutions; in this way, all banks were set to manage risk on a consolidated basis.

Since 1998, Australian financial institutions have been regulated by the Australian Prudential Regulation Authority (APRA),[4] which assumed prudential regulation functions previously undertaken to some degree by the RBA. While APRA focuses on the stability of authorized deposit-taking institutions (ADIs),[5] since 2001 the Australian Securities and Investment Commission (ASIC) has been responsible for the regulation of financial products. The RBA retains responsibility for monetary policy and systemic stability in the whole financial system.[6] Senior representatives of the RBA, APRA, ASIC and Department of the Treasury comprise the Council of Financial Regulators, which is the coordinating body for Australia's main financial regulatory agencies.

[3] Total individual losses in the banking system represented 36% of the aggregate level of shareholders' funds. In particular, state government owned banks' individual losses represented 187% of shareholders' funds. Some major banks, such as Westpac and ANZ, also experienced significant losses.

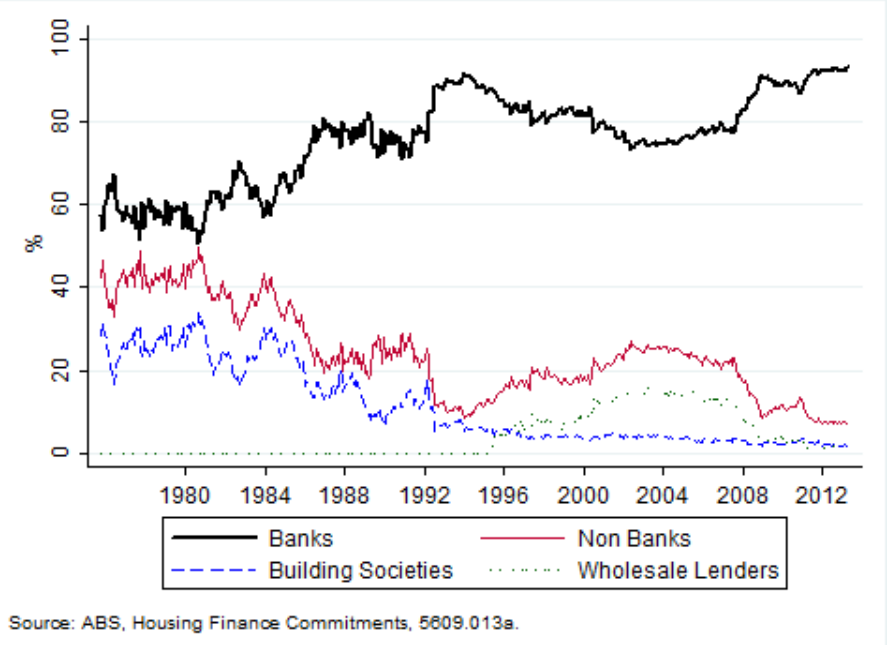
[4] APRA regulates banks, general and life insurance companies, superannuation funds, credit unions, building societies, and friendly societies to ensure that these institutions remain financially sound and able to meet their obligations to depositors, fund members, and policy holders. www.apra.gov.au

[5] ADIs are institutions that are licensed and regulated by APRA under the *Banking Act* 1959. APRA has focused on the balance sheet soundness of these financial institutions through specific balance sheet requirements such as capital adequacy rules and general supervisory oversight following Basel Committee recommendations.

[6] A Payments System Board was established within the RBA with the responsibility to promote safety, competition, and efficiency within the payments system. Other important players in Australian financial regulation are as follows: Auditing and Assurance Standards Board (AUASB), Australian Accounting Standards Board (AASB), Australian Transaction Reports and Analysis Centre (AUSTRAC), Financial Reporting Council (FRC), Financial Reporting Panel (FRP), Insolvency and Trustee Service Australia (ITSA), and the Australian Department of Treasury.

After the financial instability of the early 1990s, banks shifted their focus toward lower risk-weighted assets such as housing loans. Prior to 1980, banks held on average 60 percent of owner-occupier housing finance commitments; this share rose through the 1980s and 1990s. By 1994, the domestic banking system provided 92 percent of the residential housing credit; see Figure 2.1.

FIGURE 2.1: Housing Finance Commitments (%, volume)



During the second half of the 1990s, competition increased with the introduction of new players in the market. International lenders, who entered the market between 1985 and 1993, and wholesale mortgage originators and mortgage brokers,[7] who joined around 1996, further stimulated competition. Financial deregulation and the entry of new lenders gave rise to a wider range of financial products offered. During this period, most mortgages were a fully documented, full-recourse, variable-rate loan; fixed-rate

[7]Wholesale mortgage lenders originate and service loans, and sell them to the secondary market, and have contracting functions performed for them by mortgage brokers; see http://www.abs.gov.au/Ausstats/abs@.nsf/glossary/5609.0. In particular, a mortgage manager is a licensee who manages a mortgage relationship between a credit provider and a consumer under his own branded name; see *National Consumer Credit Protection Legislation* (NCCP), *Regulation 26*. Mortgage managers are non-bank lenders mortgage specialists who organize mortgage funding from a variety of funding sources and package their own mortgage product. Mortgage brokers, on the other hand, are intermediaries offer mortgages from several lenders to consumers in return for a commission. Banks without well-developed and with costly branch networks may provide funds to mortgage managers and offer their products through mortgage brokers.

mortgages (FRM) represented less than a quarter of the mortgage market.[8] Non-bank lenders introduced low-documentation loans, along with riskier loans such as interest-only loans and revolving credit lines. Home equity loans[9] were introduced to the market around 1996 but grew in popularity from 2003.

Lending standards relaxed over the period. Before deregulation, lending standards were quite conservative, with a maximum debt service-to-income ratio of 30 percent[10] and loan-to-value ratios (LTVs) of a maximum of 80 percent. As a result of deregulation and increased competition, measures of disposable income and property valuation methods were redefined and relaxed. Higher LTVs were available, backed by private loan mortgage insurance (LMI). The increase in the number of loan arrears in the first part of the twenty-first century could be attributed to the relaxation of lending standards; nevertheless, loan arrears in Australia are very low relative to international standards.[11]

The overall effect of deregulation for the financial system was an increase in the supply of credit and a reduction in the cost of credit. In the next section, I focus on the players in the housing credit market before the GFC, first discussing the providers of housing credit and then giving an overview of the demand for housing loans.

2.2.1 Mortgage lenders - pre-GFC

The housing credit market has played an important role in Australia's financial system. Historically, mortgage originators, principally ADIs, held around half of the total assets in the financial system; see IMF [115] and IMF [116].

ADIs comprise domestic and foreign banks, building societies, and credit unions, although banks hold around 96 percent of the total assets held by ADIs. The first panel of Table 2.1 provides a snapshot of the evolution of the number of ADIs in the Australian mortgage market. For the last twenty-five years, the Australian banking system

[8] In the Australian context, fixed-rate mortgages are loans with a set interest rate for a minimum period of two years; see ABS, Housing Finance Commitments 5609.09a, http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5609.0Aug%202014?OpenDocument. These type of loans are discussed further in this chapter and following chapters.

[9] Described in Section 2.4.

[10] This was a 'rule of thumb' of lenders, and not a regulation.

[11] See RBA, 'Box C: A Closer Look at Housing Loan Arrears', Reserve Bank of Australia Financial Stability Review, September 2011, http://www.rba.gov.au/publications/fsr/2011/sep/html/box-c.html; and RBA, 'Box B: Measurement of Housing Arrears', Reserve Bank of Australia Financial Stability Review, September 2009, http://www.rba.gov.au/publications/fsr/2009/sep/html/box-b.html.

has been concentrated around four major domestic banks.[12] During the fifteen years leading up to 2007, the major Australian banks held over 60 percent of ADI assets. The second panel of Table 2.1 shows the share of total ADI assets by type of institution. After 1990, the demutualization of building societies, together with mergers among both small and major deposit-taking institutions of all types, transformed the composition of ADIs in the credit market. In general, foreign banks operating in Australia have shown relatively little interest in retail banking, focusing mainly on wholesale funding and funds management.

TABLE 2.1: Authorized Deposit-taking Institutions (ADIs).

Number	1990	1999	2005	2010
Major Australian banks	4	4	4	4
Other domestic banks	13	8	9	7
Building societies and credit unions	330	238	170	116
Foreign-owned banks				
- subsidiaries	15	11	11	9
- branches	3	25	28	34
Total	365	286	222	170
Proportion of total assets (value)	**1990**	**1999**	**2005**	**2010**
Major Australian banks	59%	63%	65%	75%
Other domestic banks	21%	17%	14%	9%
Building societies and credit unions	9%	5%	4%	3%
Foreign-owned banks				
- subsidiaries	10%	6%	7%	4%
- branches	1%	10%	10%	9%

Sources: Gizycki and Lowe [98]; Donovan and Gorajek [75].

Prior to 1980, while 60 percent of owner-occupier housing finance commitments were held by banks, building societies held a further 25 percent (see Figure 2.1) and were offering larger average loan sizes relative to banks.[13] During the 1980s, with the introduction of foreign banks into the market, banks became even more dominant. By 1996, mortgage managers took over part of the market share previously held by building societies and

[12] The four major banks, in alphabetical order, are as follows: Australian and New Zealand Banking Group Limited (ANZ), Commonwealth Bank of Australia (CBA), National Australia Bank (NAB), and Westpac Bank Corporation (WBC).

[13] See ABS, Housing Finance Commitments, 5609.013c.

credit unions. As already shown in Figure 2.1, the non-banking sector composition changed; prior to 1996, building societies provided the majority of loans originated in this sector but were overtaken by wholesale lenders thereafter. Many building societies and credit unions became banks or merged with banks; thus, by mid-1990s, the domestic banking system provided 92 percent of the residential housing credit. Wholesale lenders also captured some bank-originated loans by offering, on average, larger mortgages than banks did.

By the early twenty-first century, while major banks approved around 60 percent of owner-occupier home loans, smaller banks held around 20 percent of residential home loan approvals; credit unions and building societies had less than 10 percent of the market share, and wholesale mortgage originators had a little bit over 10 percent; see Davies [60].

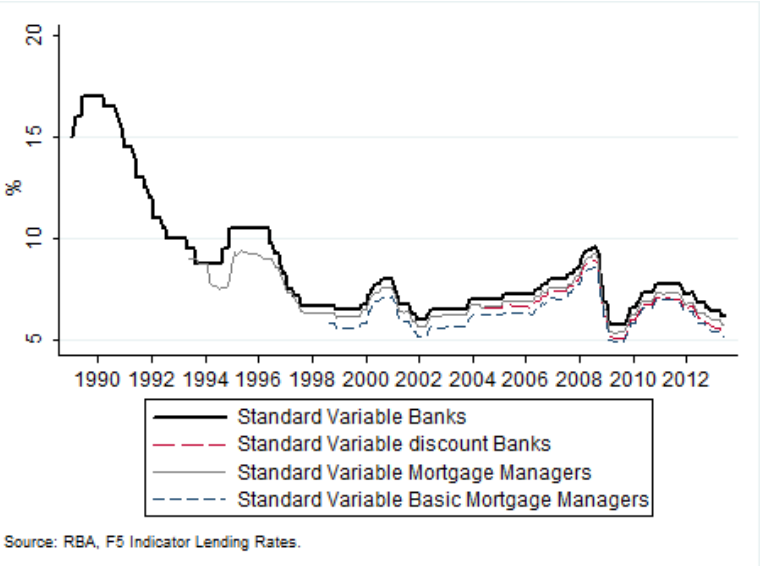
Mortgage managers have been in the market since the 1960s, holding only around 1 percent of total loan approvals until 1992.[14] Around 1995, their participation in the market grew to holding between 8-10 percent of new housing loans; see Edey and Gray [81]. A likely reason for the increasing share of the mortgage market appropriated by wholesale mortgage originators and mortgage brokers post-1996 – in particular, their rising share of refinanced mortgages – was the lower level of interest rates in the wholesale money market (their main source of funds) after the high inflation/high interest rate period. Lower inflation and the development of markets for securitized assets facilitated their funding activities. They were able to offer, on average, larger loans accompanied by lower lending rates – see Figure 2.2 – and to introduce low-documentation loans, interest-only loans, and revolving credit lines.

The participation of wholesale mortgage originators in the market was enhanced not only with technological advances but also, in particular, with the growth of the residential mortgage-backed securities (RMBS) market, which provided a relatively cheap funding source. State governments in Australia developed the first MBS programs in the mid-1980s to finance loans to low-income households. The RMBS[15] market developed

[14] See RBA, 'Box 5: Competition in Housing Finance', Reserve Bank of Australia Bulletin, Semi-Annual Statement on Monetary Policy, May 1997, Graph 3, http://www.rba.gov.au/publications/smp/boxes/1997/may/5.pdf.

[15] Australian RMBS are prime loans covered by mortgage insurance and excess spreads; see RBA, 'The Performances of Australian Residential Mortgage-backed Securities', *Reserve Bank of Australia Financial Stability Review*, March, 63-68, 2006, http://www.rba.gov.au/publications/fsr/2006/mar/html/perf-aus-res-mort-sec.html.

FIGURE 2.2: Standard Variable Interest Rates



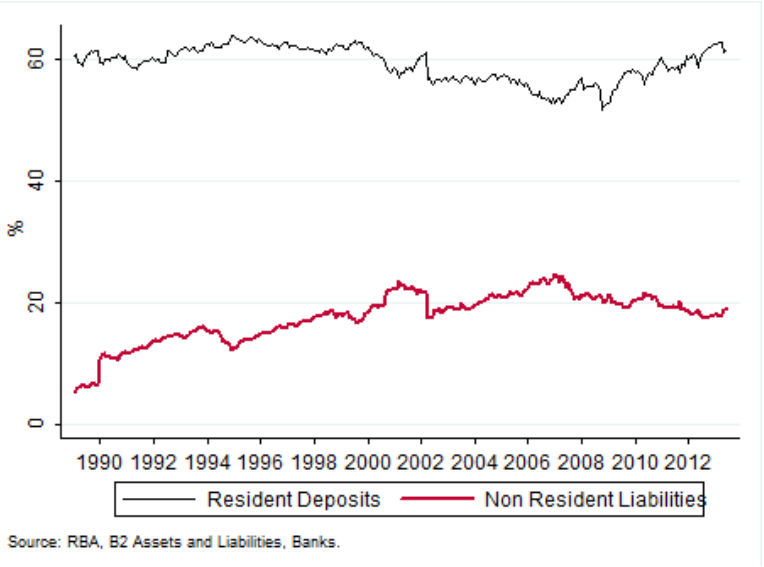
further with the growth of wholesale mortgage managers. The Australian securitization market expanded rapidly between the mid-1990s and the recent financial crisis, reaching up to 7 percent of the total assets in the financial system by mid-2007. During this period, 23 percent of outstanding housing loans had been securitized; see Davies [60]. Securitizing some part of on-balance sheet residential mortgage loans also helped ADIs to manage credit risk, release capital, and manage shareholder return to investment. However, the share of securitization in the funding composition of ADIs was always below 8 percent. The secondary market played an important role in mortgage funding for wholesale mortgage originators and, to a lesser degree, for small ADIs.

The major banks sourced most of their funding from deposits – see Table 2.2, but the expansion of household demand for credit and the reduction in the growth of deposits forced financial institutions to increasingly rely on wholesale markets for funding, mainly by issuing debt securities to non-residents. The share of the banking system's total liabilities owned by non-residents rose from below 10 percent in 1990 to over 25 percent in 2007; see Figure 2.3.

The first panel in Table 2.2 presents total deposits as a share of total resident assets for the four major banks and for some smaller domestic banks.[16] Major banks funded over 40 percent of resident assets with deposits; smaller banks relied more on deposits as a

[16]Total resident assets refer to all assets on the banks' domestic books that are due from residents. APRA refers to resident assets and resident liabilities as all operations/transactions conducted with residents that are recorded in the domestic books of licensed banks; a resident is defined as an individual,

FIGURE 2.3: Banks' Liabilities (% of Total Liabilities, value)



source of funding. The second panel displays the proportion of household deposits held by banks. One third of major banks' deposits were household deposits – except for the CBA. Table 2.3 shows the proportion of securitized assets held by banks relative to total resident assets. As evidenced in the table, securitized assets represent a marginal share of the major banks' resident assets; however, that is not the case for regional banks.

Deans and Stewart [64] show that between the years 2000 and 2005, banks sourced 45 percent of their funding from domestic deposits, 30 percent from short-term wholesale debt, and 15 percent from long-term wholesale debt. Regional banks, small credit unions, and building societies relied mainly on deposits, but had been active in sourcing their funding from the securitization market.

A narrowing in the spread between the standard variable housing loan interest rate and the RBA cash rate – together with decreasing profit margins of banks and the proliferation of new mortgage products – suggests evidence of increased competition in the housing mortgage market. As shown in Figure 2.4, the spread between the standard variable home loan interest rate and the cash rate fell from over 400 basis points in 1993-1994 to 180 basis points between 1997 and 2008 (prior to the GFC). In addition,

business or other organization domiciled in Australia (Australian branches and Australian subsidiaries of foreign business are regarded as residents).

TABLE 2.2: Assets and Liabilities of Some ADIs.

Deposit-to-resident assets ratio	2002	2005	2007	2009	2012
ANZ	49.5%	49.6%	49.1%	54.2%	60.5%
CBA	64.1%	55.4%	52.9%	56.9%	58.8%
NAB	43.0%	45.2%	41.6%	49.5%	53.7%
WBC	53.6%	54.7%	55.7%	52.7%	52.6%
Adelaide Bank	87.2%	81.5%	75.6%	(a)	(a)
Bank of Queensland	80.6%	74.4%	78.0%	79.7%	80.2%
Bendigo Bank	78.5%	78.1%	78.2%	77.3%	85.7%
Macquarie Bank	37.8%	31.3%	30.1%	35.4%	67.7%
St. George Bank	69.6%	63.8%	64.2%	53.3%	(b)
Suncorp	56.7%	60.4%	55.8%	41.4%	63.7%
Percent of deposits from households	**2002**	**2005**	**2007**	**2009**	**2012**
ANZ	34.4%	29.2%	27.2%	31.9%	33.2%
CBA	53.4%	57.0%	52.7%	45.3%	43.5%
NAB	33.6%	32.0%	33.0%	29.6%	30.6%
WBC	36.2%	33.3%	31.1%	29.4%	39.5%
Adelaide Bank	43.0%	31.8%	28.2%	(a)	(a)
Bank of Queensland	39.0%	48.5%	54.4%	61.4%	55.0%
Bendigo Bank	63.5%	58.3%	56.8%	54.0%	47.3%
Macquarie Bank	4.8%	6.0%	2.8%	13.2%	20.8%
St. George Bank	55.6%	55.2%	49.7%	57.3%	(b)
Suncorp	39.9%	41.1%	36.0%	43.6%	41.9%

Source: APRA.
(a) In November 2007, Adelaide Bank merged with Bendigo Bank, forming Bendigo and Adelaide Bank Limited.
(b) In November 2008, St. George Bank and its branch, Bank of South Australia, became part of the Westpac Group (WBC). In 2011, WBC announced the relaunch of its subsidiary Bank of Melbourne, which replaced St. George Bank in Victoria.

net interest margins[17] had been falling between 1996 and 2007, from above 4 percent to just above 2 percent for major banks, and from 3 percent to under 2 percent for smaller banks; see Deans and Stewart [64].

2.2.2 Australian demand for housing credit - pre-GFC

Home ownership in Australia has been around 70 percent for more than two decades;[18] 25 percent of Australians are renters, and 5 percent live in public housing arrangements.

[17]The net interest margins are calculated as the difference between the interest income generated by a financial institution and the amount of interest paid out to their lenders, relative to the interest-earning assets.

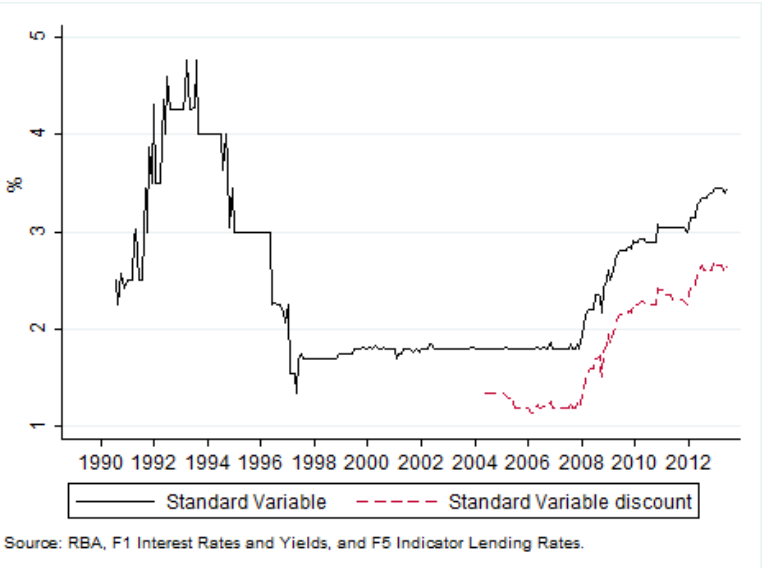
[18]See ABS, Housing Occupancy and Costs, 2007-2008, 4130.0.

TABLE 2.3: Securitized Assets of Some ADIs.

Securitized assets-to-resident assets	2002[(c)]	2005[(c)]	2007[(d)]	2009[(d)]	2012[(d)]
ANZ	1.7%	1.0%	0.4%	0.1%	0.0%
CBA	4.0%	5.3%	7.2%	1.7%	0.7%
NAB	0.6%	0.9%	1.9%	0.5%	0.1%
WBC	2.8%	1.4%	2.8%	0.9%	1.1%
Adelaide Bank	41.9%	49.2%	47.7%	(a)	(a)
Bank of Queensland	18.9%	21.6%	25.4%	18.2%	7.6%
Bendigo Bank	12.4%	3.7%	2.4%	15.6%	13.6%
Macquarie Bank	37.2%	57.0%	46.8%	27.3%	14.1%
St. George Bank	10.0%	15.6%	21.0%	9.2%	(b)
Suncorp	1.9%	9.7%	14.6%	6.5%	4.3%

Source: APRA.
(a) In November 2007, Adelaide Bank merged with Bendigo Bank, forming Bendigo and Adelaide Bank Limited.
(b) In November 2008, St. George Bank, and its branch Bank of South Australia, became part of Westpac Group (WBC). In 2011 WBC announced the relaunch of its subsidiary Bank of Melbourne, which replaced St. George Bank in Victoria.

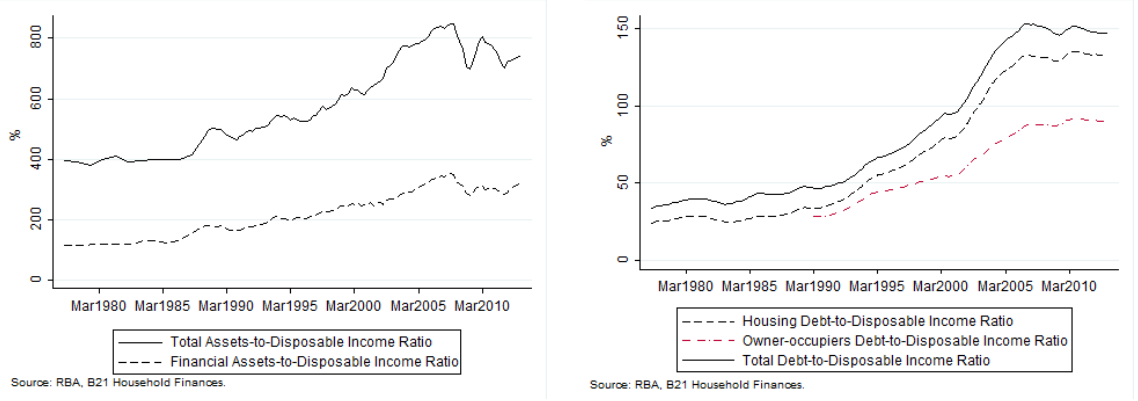
FIGURE 2.4: Standard Variable Interest Rates (Spread to RBA Cash Rate)



Half of homeowners hold a mortgage. Housing debt accounts for three quarters of the personal sector borrowings,[19] and at any one time, approximately one third of the housing stock is financed by a mortgage.

Australia has experienced a period of exceptional expansion over the past twenty years. There have been no recessions since 1990-1992, inflation has remained low and stable along with nominal interest rates, and unemployment fell from 11 percent in 1993 to 4.3 percent in 2006.[20] Over the same period, household assets relative to disposable income increased from 500 percent to 760 percent; see the left panel of Figure 2.5. In the two decades prior to 2007, the household debt-to-income ratio increased from below 50 percent to around 150 percent, and has since stabilized at that value; see the right panel of Figure 2.5. Most of the household debt accumulation was housing debt. More precisely, property debt accounted for 84 percent of all household debt in the mid-2000s. During the same period, 60 percent of total household assets were held in residential property; see Kohler and Rossiter [123].

FIGURE 2.5: Credit in Australia



Household income growth can explain part of the rise in debt and assets held on household balance sheets. Between 1980 and 1990, real net national disposable income grew by 3.1 percent per annum on average, while between 2002 and 2011, it grew by 4.1 percent per annum on average.[21] Households who experienced higher income were prepared to increase their spending on housing. However, Fox and Finlay [89] report that during this latter period, the dwelling price-to-income ratio had doubled, suggesting that

[19] See Edey and Gray [81].

[20] See ABS, Labour Force, Australia, July 2013, 6202.0.

[21] See ABS, National Accounts: National Income, Expenditure and Product, March 2013, 5206.0. Real net national disposable income per capita increased from AUD $28,000 in 1992 to AUD $45,000 in 2009.

the growth in income was not explaining all the increase in household balance sheet accumulation.

The rise in household asset (and debt) accumulation was potentially due to increasing valuation of assets such as housing and equities. Between 1980 and 1995, the average annual real house price growth was 1.1 percent, but between 1995 and 2005 this average annual growth rate was 6 percent; see Yates [191].[22] As in other countries, housing prices have risen faster than consumer prices; see Figure 2.6. Australia's nominal house prices rose by 63 percent between 2003 and 2009. Bank lending for housing finance increased by 85 percent (14.2 percent per annum) during the same period. Ellis [83] argues that as a result of disinflation, deregulation, and financial innovation, the housing credit growth resulted in an increase in housing demand, which in turn increased housing prices in the face of a highly inelastic supply. Caldera Sánchez and Johansson [39] estimate the long-run price-elasticity of new housing supply in Australia to be around 0.52. The rise in house prices was channeled through an increase in construction costs, increase in the price of existing dwellings, and mainly an increase in the price of land; it also reflects a higher average quality of dwellings.[23] At the same time, higher housing prices generated a demand for greater housing credit in an environment of rising housing equity and low interest rates. The RBA had noticed this vicious cycle and began increasing interest rates as early as 2002, in an attempt to cool the housing market down and deflate a potential housing bubble.[24]

Households increasingly invested in housing wealth, with little evidence of other household savings, with the net savings rate as low as -2 percent as a proportion of disposable income during this period.[25] Household savings have more often been oriented toward managed funds than to bank deposits, as a consequence of compulsory superannuation and tax incentives for voluntary contributions; see Connolly and Kohler [53].

Households' greater willingness to take on debt can then be explained by rising house prices simultaneously accompanied by the expansion of housing credit and the low and

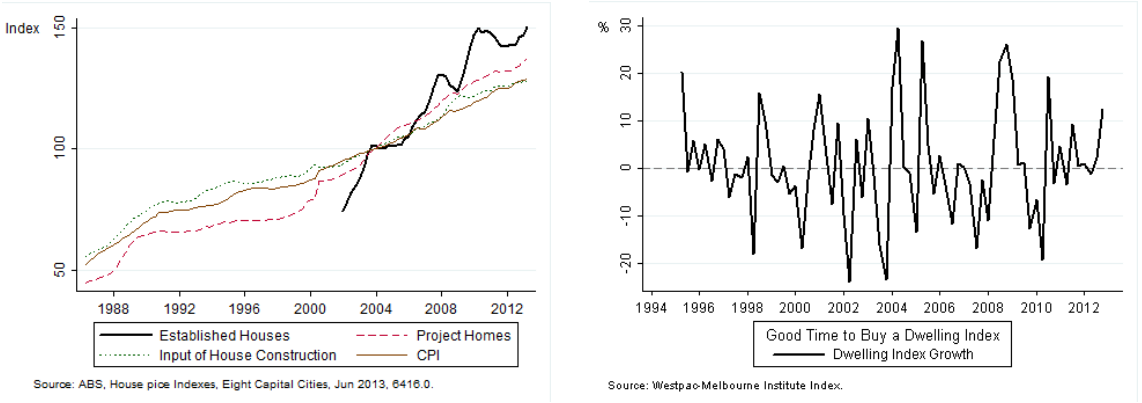
[22] According to Hansen [105], *nominal* house prices were growing on average at an 8 percent rate per annum between 1993 and 2005.

[23] Hsieh et al. [113] and Kulish et al. [126] discuss supply side rigidity of housing in Australia.

[24] On the 8th May 2002, the RBA announced an increase in its cash rate on the basis of overheating of the housing market, among other concerns; see RBA, 'Statement by the Governor, Mr Ian Macfarlane: Monetary Policy', http://www.rba.gov.au/media-releases/2002/mr-02-10.html.

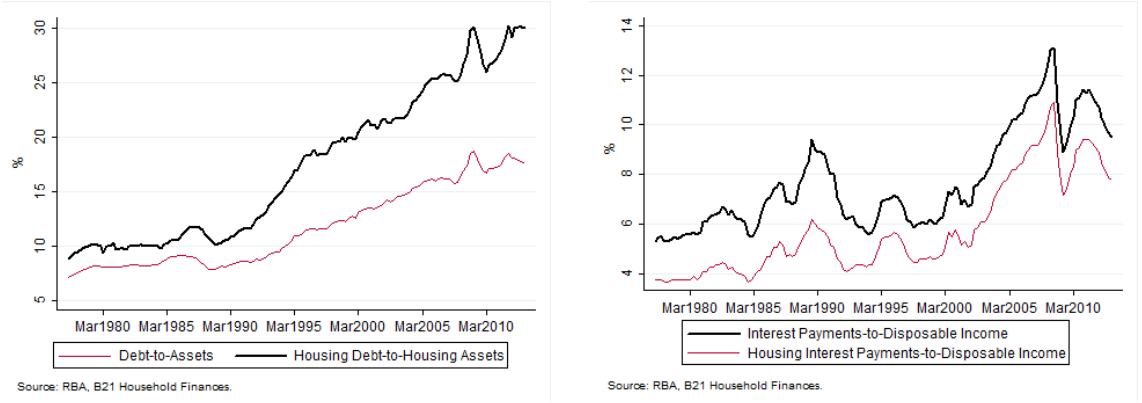
[25] See RBA, 'Box C: The Increase in the Household Saving Ratio', Reserve Bank of Australia Financial Stability Report, February 2011, http://www.rba.gov.au/publications/smp/boxes/2011/feb/c.pdf. The net saving rate is measured as the residual by subtracting consumption and depreciation from household disposable income.

FIGURE 2.6: Home Price Indexes (Index, 2003-04 = 100) and Growth in Dwelling Index



stable nominal interest rates environment - which reduced the initial real repayments for standard mortgage loans and increased borrowing capacity, see Ellis [83]. Aggregate household debt-to-gross assets rose from around 12 percent in 1995 to 25 percent in 2008. The debt service-to-income ratio (DSR) rose from 7 percent to 13 percent between 1995 and 2007, although interest rates had been falling; see Figure 2.7.

FIGURE 2.7: Australian Housing Debt



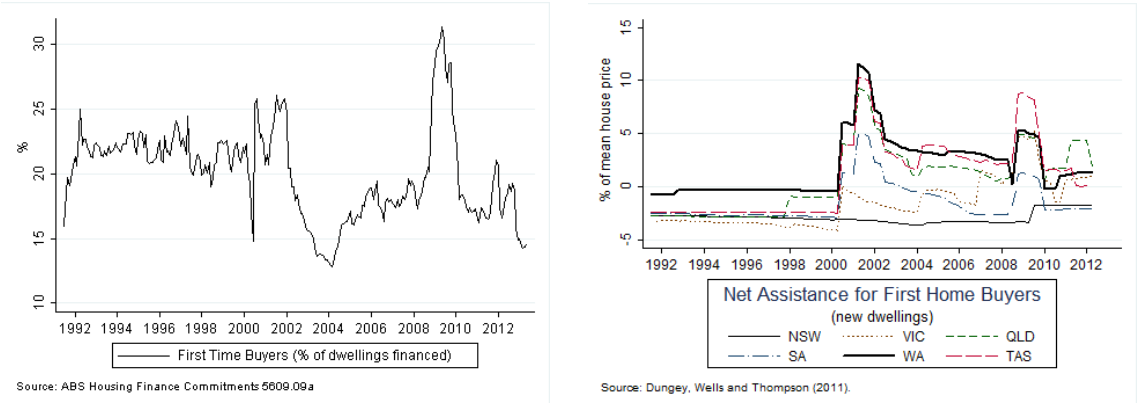
In addition, the Australian tax system provides incentives for households to make leveraged investments when asset prices are expected to increase, making owner-occupied housing and, in particular, residential investment attractive. It gives property investors incentives to participate in the housing market through the 'negative gearing' of related expenses against other income.[26] Since 1999, the capital gains tax for investors applies to nominal gains at 50 percent of the capital gains at their marginal tax rate for housing

[26]Unlike many European countries, residential investors and landlords are not constrained by rent controls in Australia.

assets held for at least a year. Investors can deduct the interest on mortgage payments and other non-cash depreciation expenses from their taxable income. Owner-occupiers have no mortgage interest deductibility but do not have to pay capital gains tax, and imputed rent is non-taxable. State stamp duty tax was levied both on the value of a purchased dwelling and on the mortgage contract, however mortgage duties have been abolished in most states; see Dungey, Wells and Thompson [77]. Many state and territory governments have provided stamp duty concessions to first-time home buyers to facilitate the latter's introduction to homeownership.

A number of other policy efforts have been implemented to promote homeownership. The Australian government introduced the First Home Owner Grant (FHOG) in July 2000, initially to offset the introduction of the goods and services tax. Under this scheme, first-time home buyers could access an AUD $7,000 cash grant when buying or building a dwelling. This Federal grant was then supplemented by state and territory government additional grants, and in some cases stamp duty concessions; for a review of first-time home buyer government assistance in Australia, see Dungey et al. [77]. The FHOG amount has varied over the years, giving preference to new buildings over existing ones, particularly in less urbanized areas; see Figure 2.8.

FIGURE 2.8: First-time Home Buyers in Australia



The proportion of dwellings financed for first-time home buyers was around 22 percent between the beginning of the 1990s until the end of 2002, as shown in Figure 2.8. Wood et al. [188] suggest that the major contribution of the FHOG was that it relaxed borrowing constraints and reduced the deposit gap. This reflects the practice of mortgage

lenders who relaxed borrower savings requirements, allowing part of the deposit to be the FHOG.[27]

However, existing homeowners constituted the main actors in the lending boom in Australia. These borrowers purchased higher valued properties with larger loans or became residential investors following the incentives given by the rise in house prices and the tax system. Most of them were aged in their 40s and had low levels of debt and a strong capacity to service new debt; see Yates [192]. In fact, the RBA reports that the arrears rate in Australia for banks' non-performing housing loans has remained under 0.5 percent since the mid-1990s.[28] At the end of March 2007, only 0.38 percent of banks' housing loans were not performing, and by the end of April of the same year, the 90-day arrears rate on securitized housing loans represented around 0.47 percent of outstanding loans; see Davies [60].[29]

Rising dwelling prices and the negative gearing incentives provided by the tax system led to growth in bank lending to investors at an annual rate of 21 percent in the 1990s, compared to 13.5 percent for lending to owner-occupiers.[30] Around the mid-1990s, the spread between the interest rates charged on investor loans and owner-occupier loans practically disappeared. A sizable share of financing products taken by investors has been interest-only loans. Table 2.4 shows housing loans for owner occupiers and investors as a proportion of total ADI loans to households during the last decade. Major banks oriented around 40 percent of their loans to households on residential housing, and 20 percent on investment housing. Smaller banks followed a similar pattern.

Overall, during the two decades prior to the GFC, Australian households and investors increased their housing credit demand as a consequence of deregulation (along with competition between lenders, and greater access to credit and new products), a stable

[27] LMI credit parameters normally require the borrower to have at least 3-5 percent genuine equity to contribute toward the purchase, as evidence of genuine saving capabilities. In 2000, LMI companies agreed to recognize the FHOG as genuine equity for the purposes of their credit parameters.

[28] See RBA, 'Box B: Measurement of Housing Arrears', Reserve Bank of Australia Financial Stability Review, September 2009, http://www.rba.gov.au/publications/fsr/boxes/2009/sep/b.pdf.

[29] See also the House of Representatives Standing Committe on Economics, Finance and Public Administration, 'Joint RBA-APRA Submission to the Inquiry into Home Lending Practices and Processes', 8 August 2007, http://www.rba.gov.au/publications/submissions/inquiry-home-lend/pdf/inquiry-home-lend.pdf. In Australia, housing loans are defined as non-performing if they are either 'past due' (repayments are at least 90 days past due, but the loan is well covered by collateral) or 'impaired' (at least 90 days past due or not in arrears but otherwise doubtful, and the loan is not well covered by collateral).

[30] See RBA, 'Recent Developments in Housing: Prices, Finance and Investor Attitudes', *Reserve Bank of Australia Bulletin*, July 2002, http://www.rba.gov.au/publications/bulletin/2002/jul/pdf/bu-0702-1.pdf.

TABLE 2.4: Loans to Households for Some ADIs.

Housing loans to owner-occupiers	2002	2005	2007	2009	2012
ANZ	38.7%	39.9%	40.8%	40.1%	43.1%
CBA	43.7%	44.4%	42.1%	47.1%	47.2%
NAB	31.9%	35.8%	34.2%	34.7%	39.0%
WBC	46.8%	41.2%	38.3%	35.1%	41.5%
Adelaide Bank	54.7%	50.2%	47.2%	(a)	(a)
Bank of Queensland	55.7%	45.5%	41.5%	42.3%	43.5%
Bendigo Bank	42.6%	40.2%	37.9%	43.2%	41.8%
Macquarie Bank	4.1%	3.5%	5.6%	8.6%	19.9%
St. George Bank	51.4%	49.5%	51.1%	51.3%	(b)
Suncorp	43.1%	36.0%	30.8%	32.5%	49.9%
Housing loans to investors	**2002**	**2005**	**2007**	**2009**	**2012**
ANZ	16.5%	18.0%	17.1%	15.8%	16.4%
CBA	18.0%	24.6%	22.6%	21.8%	22.0%
NAB	17.1%	21.5%	20.2%	18.6%	15.8%
WBC	21.2%	21.1%	19.5%	25.6%	29.7%
Adelaide Bank	22.1%	30.9%	32.4%	(a)	(a)
Bank of Queensland	3.2%	21.1%	27.8%	31.5%	36.0%
Bendigo Bank	16.1%	15.4%	16.2%	22.0%	25.8%
Macquarie Bank	3.2%	3.2%	5.2%	5.5%	13.0%
St. George Bank	19.8%	23.5%	22.0%	29.0%	(b)
Suncorp	12.3%	15.1%	15.2%	16.5%	19.5%

Source: APRA.
(a) In November 2007, Adelaide Bank merged with Bendigo Bank, forming Bendigo and Adelaide Bank Limited.
(b) In November 2008, St. George Bank, and its branch Bank of South Australia, became part of Westpac Group (WBC). In 2011, WBC announced the relaunch of its subsidiary Bank of Melbourne, which replaced St. George Bank in Victoria.

economic environment (reflected in low inflation and low nominal interest rates, low unemployment, and rising incomes and wealth accompanied by rising house price expectations), attractive taxation arrangements, and, arguably, national housing policies. However, there has been no sign of deterioration in credit quality during this period.

2.3 The Australian mortgage market: The impact of the GFC

Australia avoided a recession following the GFC, an outcome often attributed to a strong financial system with prudential lending standards and a stable domestic institutional

environment, accompanied by a resource boom linked to demand from China, and responsive and timely policy actions; see Davies [59], IMF [116], and Yates [192]. However, the GFC exposed the heavy reliance of Australian banks on capital-market funding and affected the housing credit market through increased liquidity risk for lenders. Banks played an important role in facilitating foreign investment through capital inflows, since they were heavily reliant on the overseas wholesale debt market. As a corollary, the 'credit crunch' closed funding avenues for mortgage lenders, and in turn, they contracted the credit given to households.

The main effects of the global recession on Australia were as follows: (1) an increase in the cost of funding for lenders, (2) a deceleration in household debt and asset growth, as a consequence of a slowdown in credit growth, and (3) a drop in policy interest rates. This Section discusses first the Australian policy responses to the international financial turmoil and then focuses particularly on the supply of, and demand for, housing finance.

2.3.1 Policy responses to the GFC

The RBA took its first policy action to the crisis by cutting the policy rate from September 2008, and cuts continued for a year;[31] see Figure 2.9. However, between October 2009 and October 2011, interest rates crawled up to 4.75 percent. In November 2011, the RBA decided to cut interest rates again to support demand as a reaction to uncertainty surrounding the European debt crisis and the slowdown in Chinese growth.[32] The most recent drops in interest rates have been aimed at maintaining credit growth and house price growth, among other concerns; however interest rates have been stable in the year since September 2013.[33]

With the intention of supporting the RMBS market and, with it, wholesale mortgage lenders, in September 2008, the Australian Office of Financial Management (AOFM) purchased AUD $8 billion in RMBS.[34] Half of the amount purchased was targeted to non-ADI mortgage originators. This measure was a reaction to the limited issuance by securitizers within Australia – this market was initially restricted by the contraction

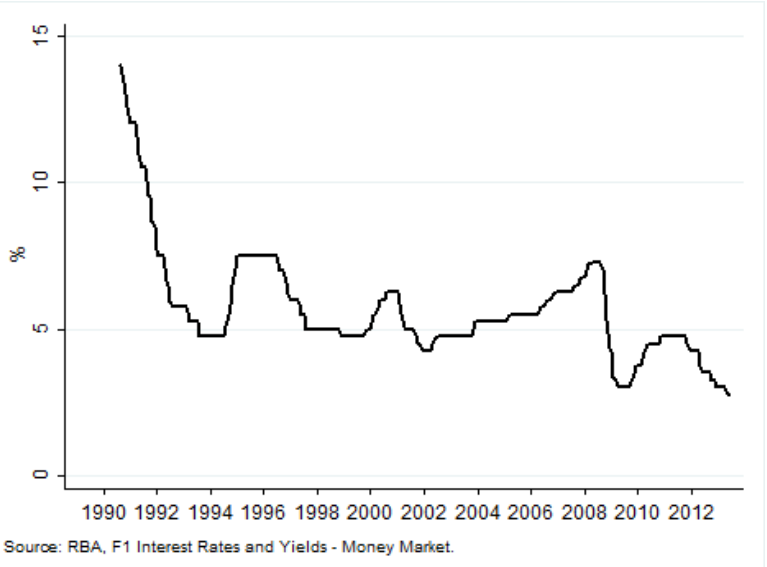
[31] During September 2009, the cash rate was 3 percent. More recently, in August 2013, the RBA cut interest rates further to 2.5 percent, which represents a 50-year minimum.

[32] See RBA, 'Statement by Glenn Stevens, Governor: Monetary Policy Decision ', November 1 2011, http://www.rba.gov.au/media-releases/2011/mr-11-24.html.

[33] See RBA, 'Statement by Glenn Stevens, Governor: Monetary Policy Decision ', August 6 2013, http://www.rba.gov.au/media-releases/2013/mr-13-15.html.

[34] All monetary values in this section are constant and in Australian dollars, AUD $.

FIGURE 2.9: The RBA's Cash Rate



of liquidity in international capital markets. The program was reinforced in October 2009, with a new purchase of AUD $8 billion in RMBS, and another AUD $4 billion in December 2010. To support liquidity in the market, the RBA expanded the range of securities for its repurchase agreements to include RMBS.

Fiscal policy also contributed to supporting the economy with an AUD $10.4 billion fiscal stimulus in October 2008.[35] This *Economic Security Strategy* was oriented first to households, through a direct one-off payment incentive to encourage consumption expenditure; it then targeted the construction industry through first-time home buyer grant incentives; the last stage focused on fostering long term infrastructure investment. The government supported this strategy in February 2009 with the *Nation Building and Jobs Plan* stimulus package, worth AUD $42 billion, to be implemented over four years; see Swan and Tanner [179]. Therefore, while monetary policy aimed at supporting the sources of funding for mortgage providers, fiscal policy stimulated housing consumption.

Financial system support also played a very important role. Some basic structures were already in place. The Council of Financial Regulators controls and regulates the financial system. APRA's capital standards for ADIs closely follow those set by the

[35] See Commonwealth Ombudsman, 'Administration of the economic security strategy payment. An examination of the implementation, monitoring and review of the scheme', *Report No. 16/2009*, 2009, http://www.ombudsman.gov.au/files/investigation_2009_16.pdf.

Basel Committee,[36] and APRA has enforced compliance more stringently (and earlier) relative with many other countries. For example, APRA and RBA had been assessing financial stability through stress tests during 2003 and 2005, as a result of emerging concerns around the rise in household debt and house price growth;[37] see APRA [13], Coleman et al. [51], and APRA [15].

The response to the financial turmoil in late 2008 was aided by the existing regulatory standards. Under the *Banking Act 1959* (subsection 11AF(3)) and following Basel capital accords, high LTV loans attract a 100 percent risk weight. However, APRA's prudential standards (APS112) allow all ADIs to obtain a concessional risk weight of 50 percent on high LTV (over 80 percent) residential loans with approved LMI. The implementation of sectoral capital requirements in 2004 as macroprudential policy aimed at containing excessive credit growth by affecting the residential credit supply-side directly.[38] In addition, the AOFM securities lending facility, established in 2004 to prevent failure in secondary market trades, was heavily used when the Commonwealth Government Securities (CGS) market became illiquid during 2008. However, a range of new policies were also developed as a reaction to the international crisis.

LMI has been in place since 1965.[39] It provides private insurance to lenders in the event of borrower default on a residential mortgage loan; the cost is borne by the borrower. Its initial objective was to facilitate the entry of first-time home buyers to the mortgage market. ADIs and wholesale mortgage lenders also acquire LMI in order to transfer credit risk from their loan books and as a credit enhancement tool to gain access to wholesale funding through the mortgage-backed securitization markets. By 2003, non-bank mortgage managers and originators insured all loans irrespective of the LTV,[40] while major banks insured 20 percent of their mortgages; see ICA [114].

[36] APRA implemented the Basel capital accords released in 1988 during the early stages, and Basel II capital accords in January 2008. See APRA,'The implementation of Basel II in Australia, *APRA Insight*, Issue Two 2008, http://www.apra.gov.au/Insight/Documents/Insight_Issue_2_2008_implementation_baselII_aust.pdf.

[37] APRA had also experienced the need for more regulatory supervision with the failure of a major insurance company (HIH) in March 2001.

[38] See IMF (2013), 'Key aspects of macroprudential policy - background paper', *IMF policy paper*, June 2013, http://www.imf.org/external/np/pp/eng/2013/061013C.pdf. See APRA's risk-weighting scheme for residential mortgage loans based on loan-to-value ratios (LTVs) at: APRA (2013), 'APS 112 Capital Adequacy: Standarised Approach to Credit Risk', http://www.apra.gov.au/adi/PrudentialFramework/Documents/Basel-III-Prudential-Standard-APS-112-(January-2013).pdf.

[39] LMI is regulated by APRA under the *Insurance Act*, 1973, and the *General Insurance Reform Act*, 2001.

[40] Generally, when LTVs are above 80 percent, mortgage managers pass the LMI premium onto the borrower.

In October 2008, the Commonwealth government introduced the *Financial Claims Scheme* (FCS), which established a guarantee of deposits of up to AUD $1 million per account holder per Australian ADI. At the same time, a fee-based *Guarantee Scheme* for wholesale funding (with a rolling maturity of five years) and large deposits[41] (over AUD $1 million) was introduced with the intention to assure ADIs' access to funding. These guarantee schemes not only assisted ADIs to access funding but also provided confidence in the capital markets and ensured that Australian financial institutions were not disadvantaged compared with international institutions with existing deposit guarantee schemes.[42] The fee for the *Guarantee Scheme* was lower for institutions with higher credit rating. By 2010, the *Guarantee Scheme* covered 7.5 percent of total ADI liabilities, mainly long-term wholesale funding; it covered 15 percent of the value of all wholesale liabilities and 1 percent of the value of total large deposits (more than AUD $1 million). The wholesale funding guarantee was removed for new liabilities in March 2010, and banks have been 'buying back' insured bond issues as international interest rates have fallen. The FCS remains as a guarantee for deposits up to AUD $250,000 since February 2012.

All of these measures helped domestic financial institutions, but as the GFC advanced, more adjustments have been made. In October 2011, the government introduced legislation to allow ADIs to issue covered bonds.[43] The intention with this legislation was to facilitate funding diversification by allowing ADIs to access low-risk (and lower funding cost) and longer maturity debt securities held on issuers' balance sheet. By March 2013, banks issued AUD $50 billion in covered bonds since their introduction, with a AAA credit rating. Additionally, customer protection has extended to mortgage markets. For example, in July 2011, the federal government banned exit fees on variable home loans with the intention of simplifying customer transitions between lenders; see Rudd and Stewart [161]. Mortgage markets are also under scrutiny in the Financial System Inquiry (2013)[44] and the Competition Policy ('Harper') Review[45] currently in process.

[41] This is formally known as the Australian Government Guarantee Scheme for Large Deposits and Wholesale Funding. For an insight on the scheme, see Schwartz [169].

[42] See Schwartz [169], Claessens et al. [49], and Demirgüç-Kunt et al. [70].

[43] The legislation is the *Banking Amendment (Covered Bonds) Act* 2011, http://www.comlaw.gov.au/Details/C2011A00125. Covered bonds are bonds, notes or other debentures issued by an ADI and secured by the cash flows from mortgage loans. Under the legislation, ADIs must limit the value of their cover pools to a maximum of 8 percent of their assets.

[44] See http://fsi.gov.au/, and http://fsi.gov.au/files/2014/07/FSI_Report_Final_Reduced20140715.pdf.

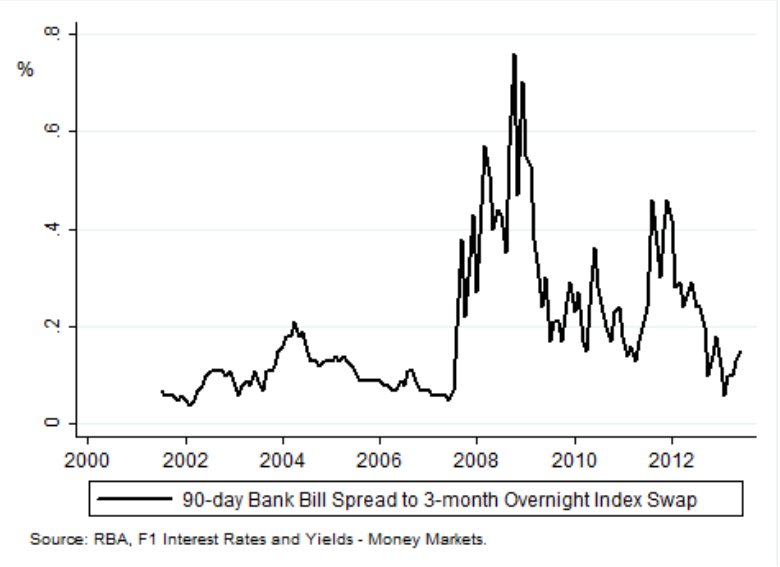
[45] See http://www.australiancompetitionlaw.org/reports/2014rootbranch.html.

To date, Australia has a well-capitalized, although concentrated, banking system. APRA intends to implement Basel III standards for capital ahead of schedule. The RBA will create a committed liquidity facility in 2015, under which ADIs will be able to access liquidity using repurchase agreements outside normal market operations in exchange for a fee. This initiative will help ADIs meet the Basel III proposed liquidity coverage ratio (LCR).[46]

2.3.2 Market reaction - supply of housing credit during the GFC

The impact of the GFC for Australian ADIs resulted in increases in wholesale funding costs, particularly for longer maturities, and reduced access to longer-term funding sources; see Deans and Stewart [64].[47] Figure 2.10 portrays the spread between the bank bill yield and the overnight index swap (OIS) yield, showing high peaks commencing in late 2007, reflecting credit and liquidity risks.

FIGURE 2.10: Money Market Rates



Major banks increased their use of deposits and reduced their use of short-term debt, even though they could still access expensive short- and long-term debt, given their strong credit ratings. The regional banks cut the use of securitization and increased their use of deposits, as shown previously in Table 2.2. Foreign banks have also reduced

[46] See http://www.rba.gov.au/media-releases/2011/mr-11-25.html and http://www.apra.gov.au/adi/Publications/Documents/130808-CLF-letter-final.pdf.

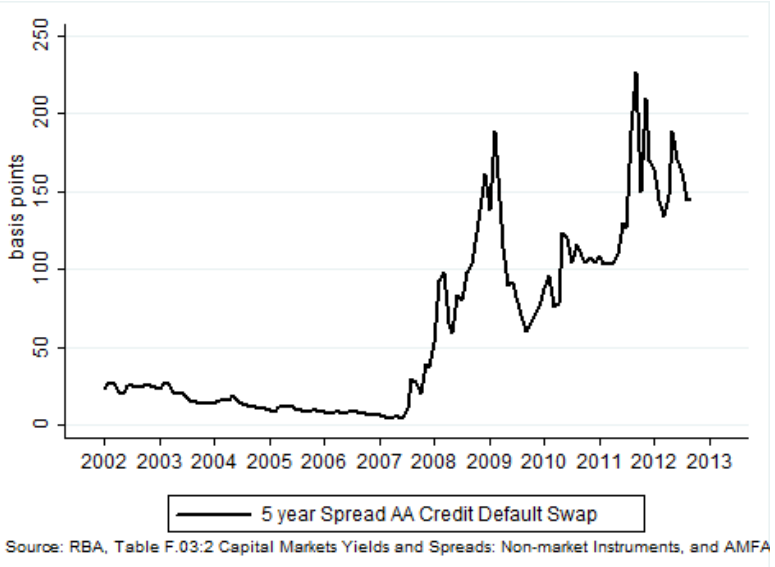
[47] For more information on the recent developments in the domestic market for short-term debt securities, see Boge and Wilson [27].

their use of long-term wholesale debt and domestic deposits. Credit unions and building societies continued raising the vast majority of their funds via deposits, with no support from an inactive securitization market; see Brown et al. [32]. Banks have also been trying to increase their common equity in recent years by retaining earnings and by share placements. Additionally, major banks have raised funding from covered bonds since October 2011.

Between July 2007 and early 2009, the securitization market in Australia was disrupted. The developments in the credit default swap (CDS) market are a good indication of this impact, as the perceived risk of banks around the world peaked; see Figure 2.11. The previously rapid growth in domestic securitization (of primarily residential mortgages) slowed dramatically, while international issues largely ceased despite the low-risk nature of Australian securitized products. Non-ADI mortgage originators relied heavily on this source of funding, while small regional banks, credit unions, and building societies had been increasing their sourcing from the secondary market. As previously mentioned, major banks used securitization only marginally. Consequently, wholesale mortgage originators, smaller banks, building societies, and credit unions became less competitive, finding it harder to raise funding and offer competitive interest rates relative to major banks. To maintain some level of securitization activity, particularly for smaller ADIs and non-ADI mortgage lenders, the Treasurer directed the AOFM to invest up to AUD $20 billion to support securitization markets, as discussed in Sub-section 2.3.1. Since 2009, the securitization market has recovered but remains below pre-crisis intensity.

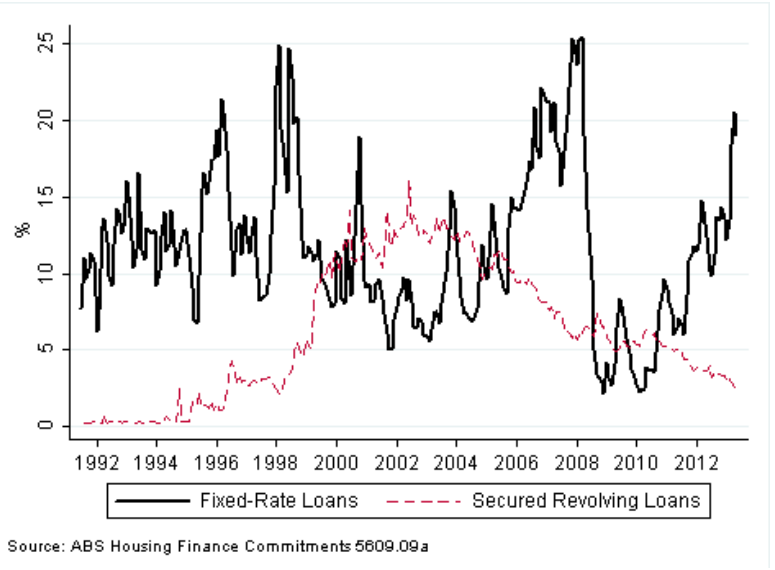
The increasing share of funding sourced from deposits and the shift away from short- to long-term wholesale funding – facilitated by government guarantees – suggest both that the alternative sources for funding were restricted or hard to access. It also suggests that major banks have sought to reduce their rollover risk – the risk associated with replacing maturing wholesale debt. These trends are consistent with the objectives of the Basel III global liquidity standards. If banks are taking more long-term debt, rather than short-term debt, they are expecting interest rates to increase – they are taking a fixed-rate position, and offering a variable-rate to consumers, in order to gain by speculating with a rise in interest rates. The drop in the number and proportion of fixed-rate mortgages transacted supports this hypothesis. In Australia, fixed-rate mortgages are defined as loans with a set interest rate for a minimum period of two years. Figure 2.12 shows that the proportion of fixed-rate mortgages committed reached an all-time low between

FIGURE 2.11: 5-year Spread AA Credit Default Swaps



2007 and 2009. Fuster and Vickery [92] find a similar result for the U.S., and argue that FRM supply drops when banks are unable to securitize loans.

FIGURE 2.12: Fixed-Rate Mortgages (%, volume)

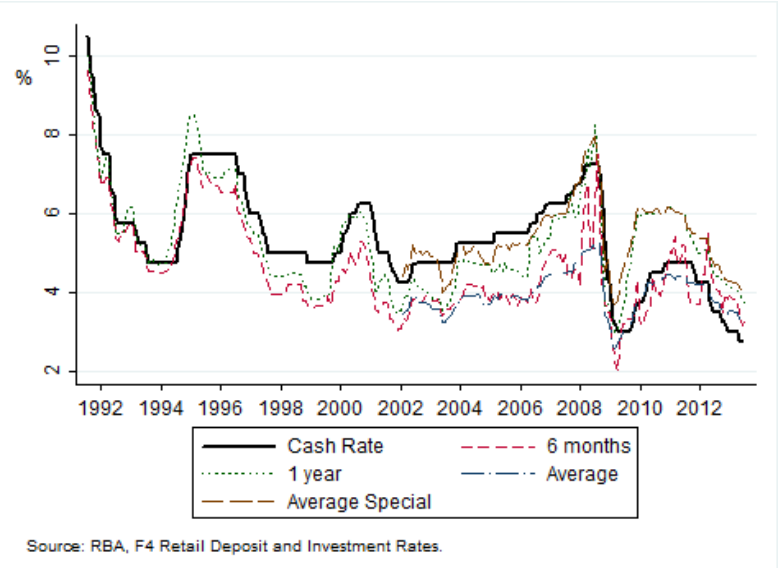


Major banks have focused on domestic deposit funding, mainly through term deposits.[48] Domestic deposits increased from around 43 percent of liabilities to around 53 percent in the 4 years following 2008. The increased usage of deposit funding is likely to be reinforced by Basel III liquidity requirements, which in general, give greater weight

[48] Robertson and Rush [158] argue that since 2012, the growth in deposits has been in at-call savings.

to retail deposits as stable sources of funds and also induce use of longer-term funding instruments. This competition for domestic term deposits has pushed term deposit rates up, as shown in Figure 2.13 by the reversal in the relationship between the cash rate and term deposit rates since 2009.

FIGURE 2.13: Bank Term Deposit Rates (AUD $10,000).



Major banks' competition for domestic deposit funding has significant implications for smaller institutions that primarily rely on this source of funding. This competition effect, supported by the implicit government guarantee that allows major banks to enjoy a funding cost advantage, has contributed to a higher concentration of the mortgage market around the major banks;[49] this argument is supported by Table 2.1. Although in 2011 major banks accounted for approximately 75 percent of ADI assets and approved around 80 percent of residential home loans – Donovan and Gorajek [75], in 2012 the four major banks held 80 percent of banking assets and 88 percent of residential mortgages; see IMF [116].

As shown in Figure 2.4, the increased cost of wholesale debt funding, together with the higher term deposit rates in the domestic market as a result of increased competition, have been reflected in higher loan interest rates. Prior to 2007, banks' costs of funds followed the cash rate, and, generally, banks adjusted variable-rate mortgage interest

[49] Jang and Sheridan [118] argue that the increase in the banking concentration experienced in Australia following the global financial crisis was due to slower growth of smaller banks reliant on securitization and constrained by reduced access to funding, reduced lending by foreign-owned banks, and acquisitions of two medium-sized banks by larger banks in 2008. IMF [116] argues that major banks are systemically risky, given their size, interconnectedness, and complexity.

rates when the cash rate was reviewed.[50] With the GFC, this relationship weakened and the spread between the standard variable rate and the cash rate widened as the costs of funds increased for lending institutions. A further potential contributor to higher mortgage interest rates could be an increase in default risk. However, major banks reported that the expected loss rate for residential mortgage lending rose by only about 5 basis points from March 2008 to a peak in March 2010; Fabbro and Hack [85].

Funding costs rose more than the RBA target rate. The cumulative change in the cost of funding for bank spreads to the cash rate was estimated to be about 120-130 basis points higher in 2012 than mid-2007, see Deans and Stewart [64].[51] Most of the increase occurred during 2008 and early 2009, when the GFC was most intense. Since mid-2011, banks' funding costs fell, but by less than the reduction in the cash rate.

Major banks have been experiencing a small increase in their net interest margin, which reached pre-crisis heights by the end of 2009; see Brown et al. [32]. On the other hand, regional banks have been facing declining net interest margins; see Robertson and Rush [158].

2.3.3 Market reaction - demand for housing credit during the GFC

Domestic growth in both household assets and debt decelerated with the international financial contraction. The fall in equity values particularly affected retired or near retired households through their retirement savings. As shown in the left panel of Figure 2.5, global financial developments curtailed the increasing trend in the proportion of assets to disposable income. Growth in the household debt-to-disposable income ratio also stopped, as evidenced in the right panel of Figure 2.5. Credit conditions tightened, although households may also have become more risk averse after the GFC. The sharp increase in the debt-to-asset ratio in 2008 could be attributed to the decline in the value of housing assets; see Figure 2.7 and Figure 2.6; while the price of existing houses dropped between 2008 and 2009, it then returned to levels 50 percent higher than in 2003-2004.

[50] A peculiarity of variable rate mortgages (VRM) in Australia is that the variable rate in these contracts adjust at the discretion of the bank, unlike in other countries with adjustable rate mortgages (ARMs) or other VRMs that follow an indicator rate such as the Libor.

[51] The costs of individual funding sources are weighted by their share of total bank funding.

Household deposits in the ADI sector have been growing since 2007, as shown in Table 2.2; see also Connolly et al. [52]. Household direct deposit holdings have increased mainly because of asset price declines and poor returns on investments during the GFC, but also because of strong competition between banks for household deposits to replace international wholesale borrowings and the deposit guarantee provided by the government. The household net savings ratio as a percent of household disposable income has been rising since 2004, from around -2 percent to 10 percent in 2011.[52]

On the other hand, the drop in nominal interest rates has facilitated debt servicing for existing mortgages; see the right panel of Figure 2.7. Nevertheless, Yates [191] argues that asymmetries in borrowers' responses to fluctuations in interest rates could exist, as borrowers have maintained their scheduled repayments, even when interest rates have dropped, to reduce their debt faster. This suggests a passive reaction to drops in interest rates and, therefore, a maintenance of repayment schedules, which implies a faster payment of principal outstanding. Australian households tend to have prepayment buffers and be ahead of their scheduled repayments.[53] Moreover, the RBA reports that 22 percent of indebted households made substantial principal early repayments on their mortgages in 2010, compared to an average of 15 percent between 2002 and 2007.

In 2008, the fiscal stimulus policy boosted the FHOG scheme in order to stimulate construction of new dwellings, as previously discussed. Under the *Economic Security Strategy*, first-time home buyers were eligible for grants of up to AUD $21,000 for the purchase of newly constructed homes. In 2008 prices, the cash grant represented 5 percent of the median house price.[54] Many first-time homeowners took advantage of the boost; the left panel of Figure 2.8 shows that the proportion of first-time home buyers doubled during this period. Nevertheless, with house prices still relatively high, and expectations of higher house price growth, tighter lending standards, and uncertainty

[52] See RBA, 'Box C: The Increase in the Household Saving Ratio', Reserve Bank of Australia Stability Report, February 2011, (Graph C1), http://www.rba.gov.au/publications/smp/boxes/2011/feb/c.pdf.

[53] As reported by the RBA, given the tax incentives, over half of owner-occupiers are estimated to be ahead on their mortgage repayments, compared to less than 40 percent of investors; see RBA, 'Box B: Households' Mortgage Prepayment Buffers', Reserve Bank of Australia Stability Report, September 2012, http://www.rba.gov.au/publications/fsr/2012/sep/html/box-b.html.

[54] The AUD $21,000 grant provided to first-time home buyers who were building or purchasing new homes represented 4.5 percent of the median price for established houses in Sydney and 5.5 percent for established houses in Melbourne. In rural areas such as Hobart, it represented 7 percent of the median house prices; see ABS, House Price Indexes: Eight Capital Cities, Jun 2013, 6416.02.

in the real economy, currently (2014) first-time home buyer dwelling finance approval is below 15 percent.

Loan arrears increased with the GFC, but they remain at relatively low levels by international standards. Banks' on-balance sheet non-performing loans increased from 0.3 percent of all outstanding loans in 2007 to 0.6 percent in 2009. Securitized loans in arrears increased from around 0.6 percent to 1.1 percent during the same period. Non-conforming loans in arrears rose from 6.5 percent of all outstanding loans in arrears in 2007 to over 9.4 percent in 2009.

The aftermath of the financial turmoil was a deceleration and stagnation of housing credit and a tightening of lending standards. Households shifted from being net borrowers to net lenders. Despite policies aimed at encouraging housing market activity, borrowers, both owner-occupiers and investors, remain cautious in the uncertain environment.

2.4 Current mortgage products in Australia

Through twenty-five years of financial deregulation, the menu of mortgage products from which Australian borrowers may choose has been extended. This section presents an overview of mortgage products offered in Australia in 2014.

The most common home loan product offered in Australia is the variable-rate mortgage, accounting for approximately 80 percent of all mortgages and 60 percent of all owner-occupier residential mortgages. Ellis [83] observes that in countries where mortgage interest payments are not deductible for owner-occupiers (as is the case in Australia), variable-rate loans are the predominant mortgage type. Non-interest deductibility gives incentives to owner-occupier mortgagees to make frequent pre-payments. Variable-rate mortgages offer an interest rate that fluctuates following the cost of funds of the mortgage originator, and, generally, the interbank cash rate reported by the RBA. The major banks have typically added a spread of around 180 basis points to the RBA cash rate; however, in recent years this spread has been wider, reaching 300 basis points; see Figure 2.4.

Other variable-rate products are also available. 'Honeymoon' mortgages generally provide some discount on the variable rate for a fixed period of time, also called a 'teaser' rate, and have fewer loan features – for example, offset accounts[55] are not offered. 'Honeymoon' loans have the lowest associated advertised interest rates.

For these variable-rate mortgage products, early or additional repayments are not generally penalized, and repayments can sometimes be redrawn. Because mortgage interest is not tax deductible, a redraw facility offers a relatively risk-free after-tax vehicle for short-term savings for many households. The maximum loan amount is 80 percent of the valuation of the property, but it could be up to 90-95 percent if borrowers take LMI. These types of loans require an establishment fee and a monthly loan service fee, which loan officers sometimes waive or negotiate. These loans do not offer a rate-lock option,[56] but they may offer an interest-only option.

Fixed-rate home loans represent currently around 20 percent of the mortgages taken in Australia; see Figure 2.12. Historically, fixed-rate mortgages have represented around 12 percent of all mortgages in Australia. The current high proportion of fixed-rate home loans is likely due to current low interest rates. These mortgage products offer certainty of repayment for a fixed period and then reset into a variable interest rate mortgage. Interest rates are generally fixed between 1-5 years but could be fixed for up to 10-15 years. Most fixed-rate mortgages do not exceed a 5-year fixed interest period. Interest rates increase with the length of the fixed period. Early repayments are highly penalized, with the borrower compensating the bank for the present discounted value of its lost income stream. A rate-lock option, offset account, and additional repayments are accessible during the fixed-term of the loan, but the latter can only be made up to a pre-set tolerance amount. A repayment redraw option can only be used once the fixed-rate period is over, and an interest-only option may be available.

In general, all these mortgage products can be contracted for a maximum term of 30 years, with a typical loan term of 25 years; interest is compounded daily, and repayments can be made weekly, fortnightly, or monthly. The aggregate average LTV is 67 percent

[55] Offset accounts are a savings or transaction account associated with the mortgage account. The credit balance of the transaction account is offset daily against the outstanding loan balance, reducing the interest payable on the mortgage.

[56] The rate-lock option refers to the advertised interest rate at the time of application being kept fixed for a maximum of 90 days in exchange for a fee.

(median 72 percent); see APRA [14]. Options to switch loans and loan portability are generally available, although not commonly exercised; split loans are also offered.[57]

Home equity loans,[58] secured on a registered mortgage over the residential property, originated in the mid-1990s and became relatively popular around 2006, probably as a result of the strong growth in house prices. A home equity loan is a line of credit secured on the equity of the existing property. These are very distinctive loans. Borrowers taking a home equity loan need to be existing mortgage holders with the institution or outright owners of their property, and most of them are re-negotiating their terms. Line of credit funds from the home equity are available for any personal use, and they can be accessed in diverse ways. The advertised interest rates for home equity loans are relatively high, and an establishment fee and annual service fee are required. The repayment frequency is not scheduled: it can be a once-off payment or a regular payment. Repayments can sometimes be redrawn, the rate-lock option is not offered, but the interest-only option is available.

Banks also offer home loan packages with discounts – subject to the size of the loan and the risk profile of the borrower – and different loan features. Examples of features include extra repayments without penalty, repayment redraw facility, top-ups, repayment holidays, and an interest offset account. Some other home loans offered include

[57] A split loan assigns a portion of the loan amount to a variable interest rate, and another portion to a fixed interest rate.

[58] Besides home equity loans, there are three other types of equity release products that are not very popular in Australia: (1) shared appreciation scheme mortgages, (2) reverse mortgages, and (3) home reversion scheme mortgages. Under a shared appreciation scheme mortgage, the borrower gives up the right to some of the capital gains on the property in return for paying reduced or no interest on the loan. Reverse mortgages are contracts where the borrower accesses a loan against the equity of their home, and the principal and interest need not be repaid until the home is sold (in the event of death of the borrower or if the borrower voluntary relinquish the property). In a home reversion scheme, homeowners sell a part or all of their home below market value but can remain in the property until the event of death or voluntary inhabitation; a sale-lease model and sale-mortgage model are also available. These products reappeared in the Australian housing credit market around 2004, after previous limited acceptance; see ASIC [16] and Alai et al. [5].

Reverse mortgages are the most popular of these three equity release products and are mainly distributed by mortgage brokers (also see *Australian Government Pension Loans Scheme*). Reverse mortgages allow senior homeowners (over 60 years old) to access the equity of their home until they decide not to live in their homes anymore or in the event of death; the lender then recovers the loan either by payment of the debt or by acquiring the property securing the loan. Repayments are not scheduled; interest and fees accumulate until the loan is repaid. The maximum loan amount and the LTV increase with age – the loan amount is capped and the maximum LTV is generally 45%. On 18 September 2008, the government introduced 'negative equity protection' on all reverse mortgage contracts, which means that the borrower cannot owe more than the equity of their home. Establishment fees and interest rates are relatively high, possibly explained by the fact that lenders need to bear longevity risk while considering adverse selection and moral hazard; see Davidoff and Welke [58].

construction loans, residential land loans, improvement loans, split loans, and residential investment property loans (RIPL).

Interest-only loans are more common for investor mortgages. Ellis [83] suggests that the mortgage interest deductibility for investors in Australia allows them to consider an interest-only loan in the expectation that the post-tax returns exceed the interest paid on the interest-only loan. Interest-only loans do not require borrowers to make repayments of principal for up to 10-15 years. The RBA reports that 15 percent of owner-occupier loans were interest-only loans in 2005, compared to 10 percent in 2003.[59] In 2005, the share of interest-only investor loans was around 60 percent, compared to around 50 percent in 2003. The IMF [116] reports that in 2012, 30 percent of new mortgages in Australia were interest-only mortgages and 55 percent of those mortgages were interest-only investor loans. The interest-only option is also available for low-documentation loans and non-conforming loans.

Low-documentation loans are those in which borrowers self-report their financial position and may be used, for example, by unincorporated businesses that are using the family home as security. During the first 5 years of the 2000s, approximately 10 percent of the value of the loans approved arose from low-documentation loans based on self-certification of repayment capacity, compared to less than 0.5 percent in 2000. Non-conforming loans provided by non-authorized deposit-taking institutions, in which borrowers do not meet standard lending criteria,[60] accounted for less than 1 percent of outstanding housing loans in 2007. Between 2000 and 2007, the proportion of non-bank on-balance sheet loans classified as non-conforming rose from 0.2 percent to 0.4 percent, and by 2011, this increased to 0.8 percent. Most non-conforming loans were issued around 2005 when lending standards were more relaxed. The average LTV for these loans is 70 percent.[61] The average LTV for low-documentation loans is around 54 percent (median 56 percent).

[59] See RBA, 'Box B: Interest-only Housing Loans', Reserve Bank of Australia Financial Stability Review, September 2006, http://www.rba.gov.au/publications/fsr/2006/sep/html/box-b.html.

[60] Borrowers typically either have poor credit histories or are seeking a loan with a LTV above 95 percent. The first specialist non-conforming mortgage provider entered the Australian market in 1997.

[61] See RBA, 'Box C: Non-conforming Housing Loans', Reserve Bank of Australia Financial Stability Review, March 2005, 41-42, http://www.rba.gov.au/publications/fsr/boxes/2005/mar/c.pdf.

2.5 Conclusion

Technological changes, greater economic and monetary stability, and financial innovation have driven the evolution of the Australian financial market in the last twenty-five years. The financial sector experienced development and growth, which resulted in considerable growth in household credit.

A number of factors contributed to the increase in household debt in Australia. Deregulation in the early 1980s resulted in an increase in the number of financing institutions and was accompanied by new financial products. Deregulation increased competition and innovation in the financial sector. The price of housing rose, consistent with the experience of other developed countries around the world. Furthermore, the expectation of growth in prices, together with the Australian tax system, promoted household investment and indebtedness. These factors are all accompanied by a transition to a lower inflation environment in the early 1990s, and therefore, lower interest rates, which enabled larger household debt.

This scenario changed with the advent of the GFC in 2007. Financial uncertainty led to credit tightening and a deceleration in household balance sheet accumulation. Australia was 'lucky'[62] in avoiding a recession during the GFC. Currently, the slow recovery of the U.S. and European economies together with a slowdown in China's growth has created concerns.

These concerns translate directly into the market for housing credit. Most borrowers in Australia hold variable-rate mortgages – which allow a direct flow of cash rate policy into mortgage interest rates, however since 2008 banks have faced higher funding costs and are increasingly divorcing their standard variable rates from the policy cash rate. Furthermore, credit growth and house price appreciation have decelerated. The financial sector is more concentrated than it was before the financial turmoil, due in part to regulator responses such as deposit insurance.

Australian regulators have been aware of, and rapidly responsive to, international uncertainty and potential flaws in the financial system. The RBA and the federal government reacted promptly to the global crisis in 2008. New measures are being put in place to

[62]See RBA Governor's, Glenn Stevens, address to The Anika Foundation Luncheon, 'The Lucky Country', 24 July 2012, Sydney – RBA Bulletin, September quarter 2012, 75-83.

face external threats – such as the European sovereign debt crisis and the slowdown in China – and potential internal flaws – such as the banking sector's potential systemic risk due to its high concentration around four pillar banks.

Overall, although major banks increased their share of financial system assets, they have changed the composition of their balance sheets and appear to hold a strong capital position and healthy funding. The household sector has shifted from being net borrowers to net lenders toward the end of the last decade with offsetting changes for the government sector. Australia maintains a sound financial system, with AAA-rated government debt.

Chapter 3

Data Description

3.1 Introduction

This chapter describes the data used in this thesis, and validates it as representative by comparison with market data. We investigate mortgage product choice observing loan-level, individual-level data for a rich sample of Australian borrowers during January 2003 to May 2009. The proprietary data, originated by one of the major banks with national representation in Australia,[1] collects borrower information in the process of a mortgage application made directly to the bank. The raw dataset includes 1.2 million mortgage applications.

Importantly, the data in this study do not rely on survey data and interpolated data. Many empirical studies on mortgage choice have been severely limited in the data available; Dhillon et al. [73] have only 78 observations, Brueckner and Follain [34] have 475 observations, Brueckner [35] has 418 observations and Sa-Aadu and Sirmans [162] have 345 observations. Moreover, each of them draw from relatively constrained geographic areas.

More recently, larger datasets have emerged, however they are compiled from representative surveys. Coulibaly and Li [54] have 2,887 observations for U.S., while Paiella and Pozzolo [150] have 28,000 observations for Italy. Cocco [50] has 3,608 mortgages for the

[1]The major bank remains anonymous, and covers mortgage applications made in bank branches around all of Australia, except for the Northern Territory – however some applicants report residence in the Northern Territory.

British Household Panel Survey, while Ehrmann and Ziegelmeyer [82] have around 8,500 observations in a Euro Area wealth survey.

The literature on mortgage choice is currently undergoing a strong resurgence, partly due to interest in the role of securitized mortgages in the propagation of the global financial crisis, and partly due to the origination and exploration of greatly improved data resources. The most convincing new evidence is emerging from datasets compiled from financial institutions or regulatory authorities' collections of data. Fortowsky et al. [88] have over 780,000 observations by combining databases from financial institutions and GSEs. Berndt et al. [26] work with over 300,000 loans generated by one of the largest sub-prime loan originators in the U.S. Amromin et al. [10] manage information on 10 million mortgages obtained from large U.S. mortgage providers. All these studies are based on the U.S. mortgage market. Individual or loan-level data are sought in many other countries, however we are not aware of any study on mortgage product choice that applies administrative loan-level data outside of the U.S.[2]

Exploiting the richness of the data is one of the contributions in this work. The information collected for a mortgage application covers not only costs and terms of the mortgage contract, but also provides bank-validated information on borrower demographics, income and financial position.

This chapter proceeds to describe in detail the raw administrative loan-level dataset in Section 3.2. Section 3.3 explains the data cleaning process. Sections 3.4 and 3.5 concentrate on the cleaned sub-samples of owner-occupier and investment loans respectively. Section 3.6 describes complementary data used to obtain indicators of the economy. Section 3.7 presents concluding remarks.

3.2 Loan-level bank originated dataset

This section presents an overview of the raw data used in this study over the sample period and validates it with aggregate national level data from the Australian mortgage market. We make no distinction between mortgage products in this section, and pool all mortgage applications together – Sections 3.4 and 3.5 describe the clean subsamples

[2]For other financial studies using proprietary data see Agarwal et al. [2], Agarwal and Qian [3], Loutskina and Strahan [140], Ambrose et al. [9], and DeFranco [69].

of owner-occupier mortgages (which we use in the subsequent chapters) and residential investment property loans (RIPL) respectively.

The data collection distinguishes three stages in the mortgage contracting process: (1) initial application, (2) offer, and (3) final stage of mortgage contracting. Mortgage characteristics, terms and costs are recorded, including debt serviceability indicators – such as debt servicing-to-income ratios (DSR) and loan-to-valuation ratios (LTVs). The dataset also contains extensive individual-level data on borrower demographics, income, expenditure pattern, wealth and financial positions at time of application. Some characteristics of the property acting as a security under the mortgage contract are also reported. The geographical information is very rich at loan-level; the dataset provides the postcodes for the current address of the borrower, the property under the mortgage, and the bank's branch where the application was submitted.

The raw data contains 1,207,291 observations and 229 variables. However, around 50 variables are complete and informative, and, after data cleaning, approximately 1,150,000 observations remain. Notably, there is a break in the series in October 2003 for which we attempt to control.[3]

I proceed to describe the information in the raw database in the following sub-sections, by distinguishing: 3.2.1 mortgage costs and the application process, 3.2.2 information on the borrower, and 3.2.3 characteristics of the property that secures the mortgage contract.

3.2.1 Mortgage costs and the application process

This sub-section presents an overview of the application process and the associated mortgage costs for all mortgage applications generated by the bank (the raw dataset). First, mortgages are characterized by purpose – owner-occupier, investment, refinance – and product – fixed-rate or variable-rate. Then, mortgage costs and terms are described across contract stages, focusing on average loan size, term, repayments, interest rates and serviceability ratios.

[3]During October 2003 most monetary variables such as loan payments, monthly expenses, salary and income have zero values.

Prospective borrowers who consider taking a mortgage usually have a meeting with a loan officer to learn about mortgage products and obtain pre-approval based on their assessed financial position. Once pre-approval is provided, a particular mortgage product is selected and a formal mortgage application is completed and submitted to the bank. The bank then assesses the application and makes a decision on whether to offer a mortgage or not to a particular borrower. Conditional on a successful application, the bank offers a formal mortgage contract to the borrower and provides more accurate associated mortgage costs and terms. Finally, the applicant can sign the mortgage contract or cancel it. In the dataset for this study 83 percent of loan applications are approved by the bank, only 0.06 percent are declined, and 17 percent are canceled by the applicant.

Although the vast majority of mortgage contracts seem to be settled on application day, on average it takes 2.5 days for the lender to inform the borrower whether the application has been accepted or rejected (some extreme cases take between 50 and 800 days).

The dataset distinguishes different mortgage purposes and products. Over half of mortgage applications are owner-occupier home loans (51 percent), 21 percent are residential investment property loans (RIPLs), while 25 percent are supplementary loans; see Table 3.1 and Figure 3.1.[4] These proportions are consistent with national levels for dwellings with secured finance, as reported by the Australian Bureau of Statistics (ABS). During the sample period, 47 percent of all dwellings with secured finance were for owner-occupiers, 35 percent were for housing investment, and 18 percent were owner-occupation refinancing of established dwellings, as shown in Figure 3.2.[5] Investors and homeowners are expected to behave differently due to the nature of housing as an investment or consumption instrument, and also because they face different incentives under the Australian tax system; see Sections 3.4 and 3.5.

The data allow the classification of mortgage applications into: variable-rate loans (63 percent), fixed-rate loans (15 percent), discounted variable-rate loans (16 percent), and

[4]Supplementary loans are home equity release loans with a fixed repayment term. Some 2.5 percent of mortgages are used to buy land and 0.6 percent are improvement loans (for house extensions for example). The spikes for the RIPLs in Figure 3.1 may be related to the end of the financial year in Australia.

[5]See ABS, Housing Finance 5609.0, Australia, Table 11, 'Housing Finance Commitments (Owner-Occupation and Investment Housing), By Purpose: Australia, ($'000)'.

FIGURE 3.1: Proportion of Mortgages by Purpose, Number of Mortgage Applications.

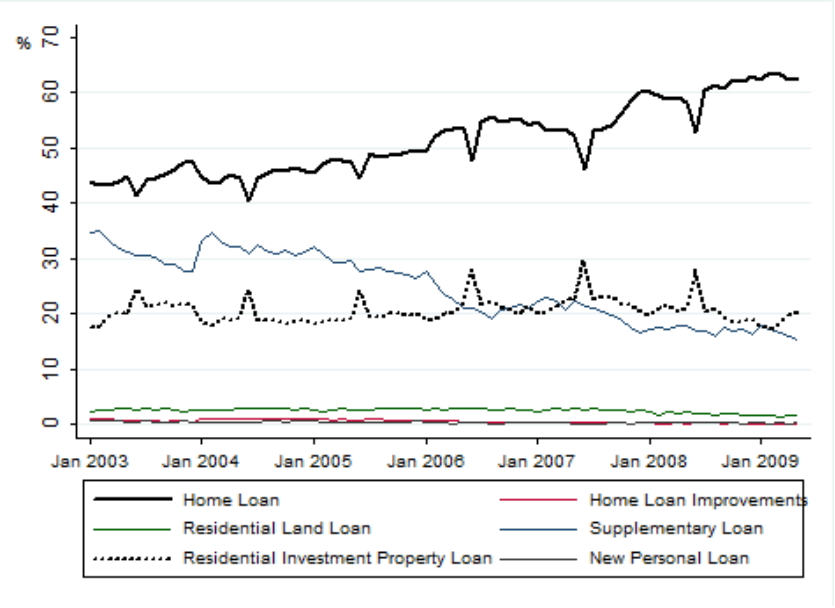


FIGURE 3.2: Proportion of Mortgages by Purpose, Value of Dwellings under Finance Commitment.

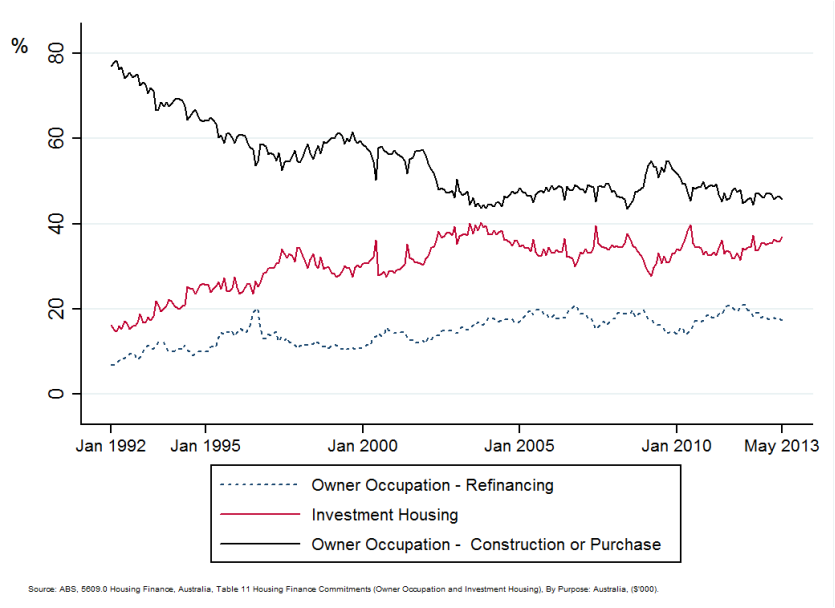


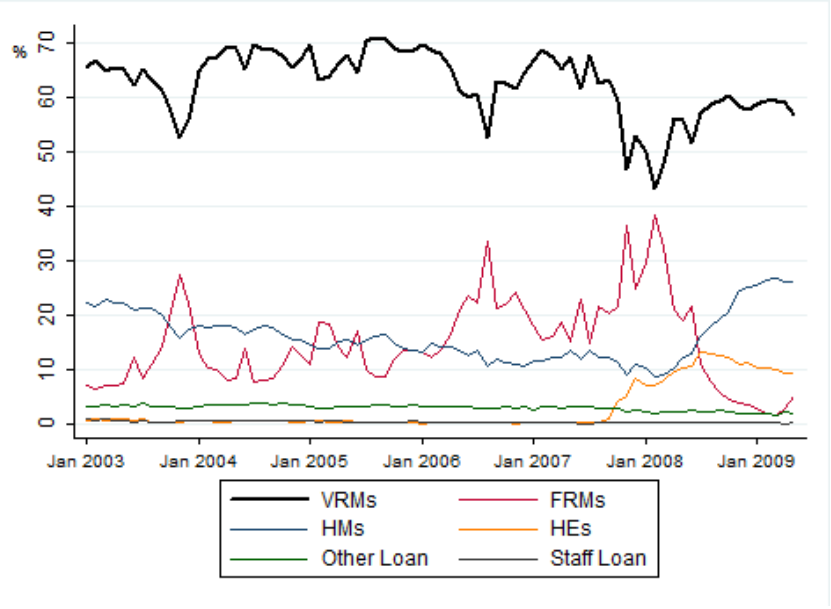
TABLE 3.1: Mortgage Products

	O/O Home Loans	RIPLs	Supplementary	Total
Variable Rate Mortgages (VRMs)	56.3%	55.2%	90.0%	62.8%
Fixed Rate Mortgages (FRMs)	15.6%	25.2%	7.9%	15.1%
'Honeymoon' Mortgages (HMs)	23.3%	19.6%	–	16.1%
Home Equity Loans (HEs)	4.8%	–	–	2.8%
Other Loans (interest in advance or home improvement)	–	–	2.2%	3.1%
Total	51.4%	20.7%	25.4%	

'O/O': Owner-occupied. 'RIPLs': Residential Investment Property Loans. Jan2003-May2009.

home equity loans (3 percent);[6] see Table 3.1. Figure 3.3 shows the evolution of these proportions over the sample period. The proportion of fixed-rate mortgages in the dataset is consistent with that reported by the ABS;[7] see Figure 3.4.

FIGURE 3.3: Proportion of Mortgages by Type, Number of Mortgage Applications.



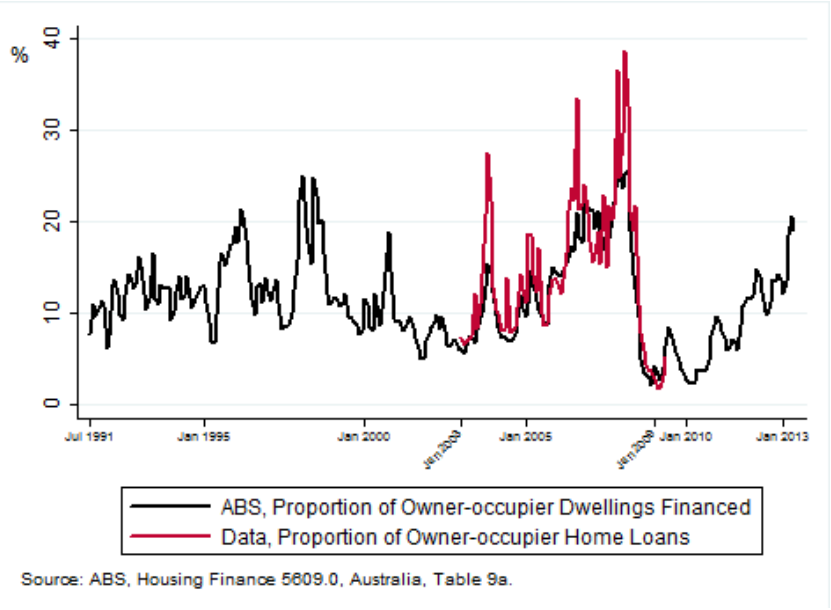
The vast majority of loans are classified as residential mortgage securities.[8] While a third of applications have had no changes to the original application, half have suffered between 1 and 3 modifications. Additionally, 4 percent of borrowers are reported as

[6] Home equity loans differ to supplementary loans in that supplementary loans are loans secured by the equity of an existing property with frequent repayments and a term for the life of the loan. A home equity loan is a line of credit secured by a mortgage on an existing property with a amount limit but with no scheduled repayments or loan term.

[7] See ABS, Housing Finance 5609.0, Australia, Table 9a 'Housing Finance Commitments (Owner Occupation), By Type of Buyer and Loan: Australia, original'.

[8] 73 percent are regulated and 97 percent of loans have a risk grade of zero.

FIGURE 3.4: Proportion of Fixed-Rate Mortgages.



holding multiple home loans and 9 percent reported having a prior mortgage with a median value of AUD $183,615.[9]

The dataset distinguishes three stages in a mortgage contract: (1) application stage, (2) offer stage, and (3) final stage. In each stage the data report: date, loan amount, number of applicants, term (life) of the loan, interest rate, repayment amount and repayment frequency (weekly, fortnightly or monthly), total contribution (amount for deposit, cash contribution and other contribution), credit score, the purchase price and the decision on the contract.

Table 3.2 shows brief summary statistics of mortgage characteristics by contract stage. At the initial application stage borrowers apply for the mortgage product that most closely satisfies their needs and preferences. The average applicant requests a loan size of AUD $215,682 during the sample period. The average loan size is smaller during the offer stage. However, at the final stage, the average loan contracted is AUD $216,069,[10] with a median of AUD $177,084. At this stage, a third of all mortgages are contracted by a single applicant, while two thirds of borrowers submit a joint application. Over half of

[9] All monetary values in this chapter are real values in 2011-12 Australian dollars (AUD $) to simplify comparison with national level data. However, the rest of the chapters show real values in Q1 2006 Australian dollars, selected as a midpoint in the time of the sample period.

[10] There is evidence of some loan size and interest rate negotiation between the stages of the mortgage contracting process.

mortgages are a 30-year contract, however the mean mortgage term is 25 years.[11] Almost half of borrowers make monthly repayments, a third make fortnightly repayments and 20 percent make weekly repayments.[12] Calculated average monthly repayments at the initial stage are around AUD $1,585. Average monthly mortgage repayments are around AUD $1,570 at the final stage. Bank fees are determined at the offer stage; they are on average AUD $809 – representing a once-off bank application fee.

TABLE 3.2: Mortgage Characteristics by Contract Stage

	Application	Offer	Final
Average loan size	$215,682	$205,428	$216,069
Average loan term	26	25	25
Average monthly repayments	$1,585	$1,514	$1,570
Average bank fees	–	$807	$809

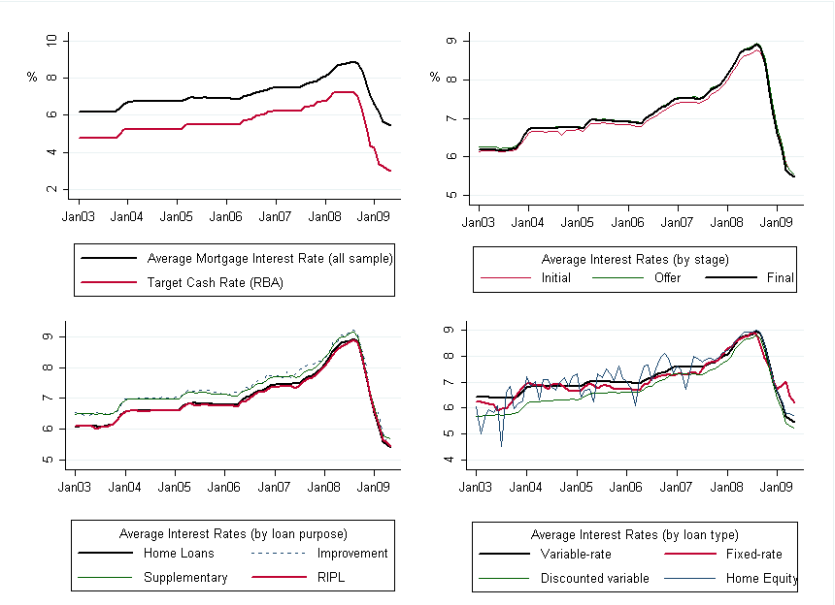
Average interest rates follow the target cash rate reported by the RBA as shown in Figure 3.5. Initial interest rates at application time are slightly lower than the ones offered and agreed on at the final stage of the mortgage contract. This discrepancy could be due to a series of reasons: the final loan size may be larger or the term of the mortgage contract may be shorter, or the final interest rates may include forward looking information relative to initial interest rates which may follow previous market assessments. However, a more likely reason could be that the final interest rate incorporates some premium based on the credit assessment of the borrower. Owner-occupier mortgages and RIPL interest rates are lower than those offered on supplementary mortgages or home loan improvement mortgages. Interestingly, during most of the period the average interest rate for a fixed-rate mortgage is lower than that of a variable-rate mortgage. This is not the case for most of the mortgage choice literature in the U.S.; Badarinza et al. [18] show that the interest rate spread between fixed-rate and adjustable-rate mortgages is always positive for the U.S. and Italy, but has been negative for some other countries, especially for Australia. Discounted variable-rate mortgages offer the lowest rates, while home equity loans show volatile average interest rates.

The dataset also reveal mortgage ratios such as payment-to-income ratio (PTIR), debt service-to-income ratio (DSR), and loan-to-value ratio (LTV). Monthly payments represent on average 21 percent of monthly net income (PTIR) for the whole sample. The

[11] Only 15 percent of mortgages in the sample have a term of 10 years or less.

[12] These results are surprising as it is common knowledge that more frequent repayments will decrease the outstanding principal faster with compounding interest.

FIGURE 3.5: Average Interest Rates.



DSR – which is calculated as annual mortgage payments, property taxes and other debt payments as a proportion of gross household income – is on average 45 percent.[13] The LTV is an important factor in the mortgage contract, with an average of 61 percent in the sample.[14] This value is consistent with national levels for the period; APRA reports an average LTV of 67 percent for Australia.[15] Figure 3.6 reveals the distributions of these financial ratios, while Figure 3.7 shows their mean trend over the sample period.[16] The LTV is relatively constant, however the DSR has an increasing trend until the global financial crisis.

The data report mortgage terms and conditions, but also reveals applicant information. The next subsection describes the raw data collection on borrower characteristics.

3.2.2 Borrower information

This sub-section describes applicant characteristics for all mortgages in the raw data.

[13] PTIR refers to the monthly mortgage payment to net income ratio, while DSR refers to all debt payment (not only mortgage debt) as a proportion of gross household income.

[14] There are some extreme values, such as LTVs over 100 percent, which mainly correspond to supplementary loans; however, more surprising are LTVs of zero – only 0.63 percent of the sample.

[15] See APRA, 'ADI housing lending', APRA Insight, Issue one, 2008, http://www.apra.gov.au/Insight/Documents/ADI-housing-lending.pdf.

[16] Note that there is a jump for both DSR and PTIR series in October 2003 due to internal recording errors generated by the bank, as mentioned in Section 3.2.

FIGURE 3.6: Mortgage Ratios, Histograms.

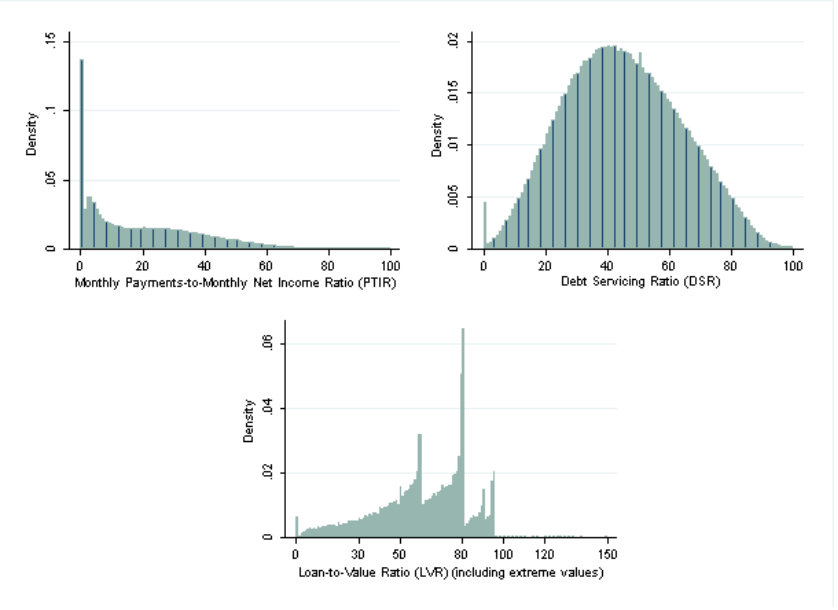
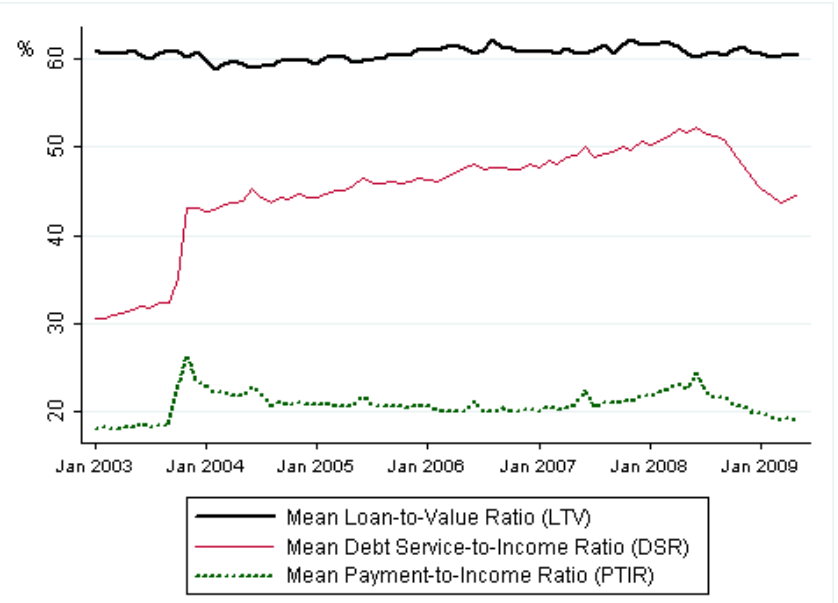


FIGURE 3.7: Average Monthly Mortgage Ratios.



The average borrower is a 42-year-old male – only a third of all main applicants are females and 90 percent of borrowers are under 57 years old. Borrowers report that they have lived at their current address on average for 7 years, and 2 years at their previous address. Similarly, they have worked at their current employment for 7 years on average, and for only 1 year at their previous employment.[17]

Family size and composition provide relevant information on the mortgage applicant. Almost 70 percent of all applicants are married or are in a de-facto relationship;[18] however 60 percent of all married and de facto applicants have no dependents. Of those applicants who have dependents – whether married, de-facto or single – the average dependent is 7 years old. Family size is on average 2.5 persons. As already stated, most applications concern more than one applicant, only a third are submitted by a single applicant.[19] Some of these joint applications correspond to married or de-facto couples (60 percent), although there is no perfect correlation between joint applications and couple status.[20]

The bank extracts information on the financial position of its borrowers. This information is extensive and, most importantly, it is validated by the lender. Borrowers are required to report income, expenditure, serviceability, and wealth information in order to assess their budgetary constraints.

Borrowers' income is crucial to assess their repayment capacity. Total average monthly real net income for the main applicant is AUD $7,195,[21] and average monthly gross income is AUD $9,483 (AUD $113,796 annually). Household total income is mainly determined by the main applicant's income. These values are consistent with ABS reports of mean gross household weekly income of AUD $2,437 for owners with a mortgage.[22] The bank records the uncommitted monthly income (UMI) reported by the borrower and

[17]Note that variables on time spent at previous address and previous employment have many zeros – 62 and 78 percent correspondingly; missing values could have been imputed as zeros by the data provider.

[18]In Australia, de-facto relationships are defined since June 1999 as all relationships between two adults (over the age of 18) who: live together as a couple; and are not married; and are not siblings or a parent or child of each other.

[19]Information on a second applicant is collected if applicable. Variables such as age, existing customer, first-time home buyer, number of dependents, income type, gross monthly salary and occupation are included, as well as time with the bank, and time at current and previous address. Credit history on the second applicant is also available.

[20]The second applicant is not necessarily the spouse. The correlation coefficient between the married or de-facto and co-borrower dummies is 0.50.

[21]The maximum monthly real net income is AUD $340,510 (the standard deviation is $5,105).

[22]This is for owner-occupiers who have a mortgage. See ABS, Household Income and Income Distribution 6523.0, Australia, 2011-12, Table 11.

also calculates it internally. Average monthly real UMI is AUD $2,527 (AUD $30,324 annually) as reported by the applicant, and AUD $2,179 (AUD $26,148 annually) as calculated by the bank.[23] The average disposable income of a mortgage applicant in the dataset is below the average national household disposable income of AUD $789 a week (AUD $41,028 annually) for the period 2002-2010, and it represents the 40th income percentile and over of the Australian population.[24] Applicants also provide their occupational category: they are mainly professionals, followed by management positions, professional skilled tradesmen and small business proprietors – 20 percent report themselves as self-employed. A small proportion of borrowers (3 percent) in the sample receive government benefits.

Additionally, borrowers are required to report expenditure patterns. Applicants spend on average AUD $1,711 (AUD $18,216 annually) on monthly payments toward credit cards, personal loans, hire purchase and other loans.[25] In particular, they report an average monthly expenditure of AUD $1,518 on current house repayments, rent and board. Applicants average monthly personal living expenses are around AUD $1,603.[26] Average real monthly non-durable expenditure is AUD $1,611. It is possible to distinguish the total monthly expenditure – mainly personal living expenses – reported by the borrower from the one calculated by the bank.[27] Average total monthly expenditure as reported by applicants is AUD $4,053, while the bank's estimates are on average AUD $5,454; only 3 percent of borrowers reported equal or higher average monthly expenditure than the one calculated by the bank.

At application time, the lender assesses the applicant's stock of wealth. Total net wealth is on average AUD $654,024 (with a median of AUD $401,376), with total assets on average AUD $903,120 (with a median of AUD $600,882), and total liabilities on average

[23] On average, borrowers over-report their UMI by AUD $349; only 8 percent of applicants reported equal or higher UMI than the one calculated by the bank.

[24] This is for all households, not just the owner-occupiers with a mortgage. See ABS, Household Income and Income Distribution 6523.0, Australia, 2011-12, Tables 1. Values are in 2011-12 dollars, as all monetary values expressed in this chapter. Real weekly average disposable household income adjusted to include imputed rent is AUD $911 (AUD $47,355 annually) for the period 2005-2010.

[25] The average monthly credit card expenditure is reported to be AUD $230.

[26] Although other expenses categories are reported in the dataset, they appear very incomplete and with missing values. Only 25 percent of applicants report monthly expenditure on utilities (on average AUD $128), 10 percent report other monthly expenses (on average AUD $576) and vehicle running expenses (on average AUD $434), and only 1 percent report monthly insurance expenses (on average AUD $122) and monthly education and fares expenses (on average AUD $246).

[27] Total monthly expenses include: expenses on other loans, credit card payments, rent or board, utility, education, tax, living, motor vehicles, superannuation, disability, and fares.

AUD $249,083 (with a median of AUD $168,053). The ABS reports that average household net worth is AUD $670,396 for the period 2003-2010, however the highest two quintiles have a net wealth over AUD $600,000.[28]

The bank collects further information on liabilities, in particular: balance outstanding on any mortgage held, balance outstanding on any other unsecured loan held, revolving credit limits and revolving credit balance outstanding. At time of application, two thirds of applicants have an outstanding balance on a held mortgage, of which a balance of on average AUD $257,940 is held with the bank, while AUD $177,593 is held with another financial institution. Around 14 percent of applicants have unsecured debt balance outstanding; the average unsecured loan held with the bank is AUD $160,907, and AUD $191,599 with another financial institution.The average revolving credit limit (from overdraft accounts and credit cards) with the bank is AUD $11,330, while the revolving credit balance outstanding is AUD $7,534.[29] Similarly, the average revolving credit limit with other financial institutions is AUD $8,623, while the revolving credit balance outstanding is AUD $9,077.[30]

Information collected on assets includes the balance on depositor accounts, and the total value of property, vehicles, shares/stocks, or other assets. On average, borrowers hold a balance of AUD $28,875 in their bank depositor account, and AUD $50,242 in other financial institutions depositor accounts.[31] The average value of existing property is AUD $748,556, with a median value of AUD $498,753. The average value of motor vehicles is AUD $30,360.[32] Only 5 percent of applicants report holding assets in shares, and the average value of shares is around AUD $64,011.[33] The average value of other assets is AUD $157,851.

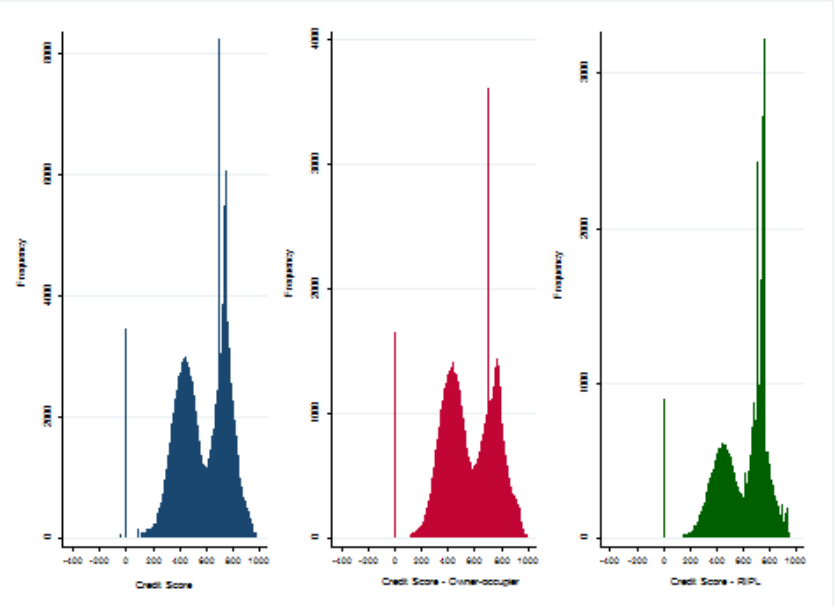
The data also provide information on the number of credit facilities and credit accounts held with the bank and with other financial institutions. Few applicants (8 percent) have one or more than one revolving credit facility with the bank, however almost 70 percent have a revolving credit facility with another financial institution. Most applicants (over

[28] See ABS, Household Wealth and Wealth Distribution 6554.0, Australia, 201112, Table 1.
[29] If we ignore the zeros (80 percent), the average revolving credit limit with the bank is AUD $57,861, of which AUD $52,464 is outstanding.
[30] If we ignore the zeros (33 percent), the average revolving credit limit is AUD $12,903.
[31] These values are relatively close to the required mortgage deposit.
[32] Borrowers report the number of vehicles they own; 83 percent own 1 or 2 motor vehicles.
[33] This sub-sample limits to the period January to September 2003.

88 percent) report no credit accounts with neither the bank or with any other financial institutions.

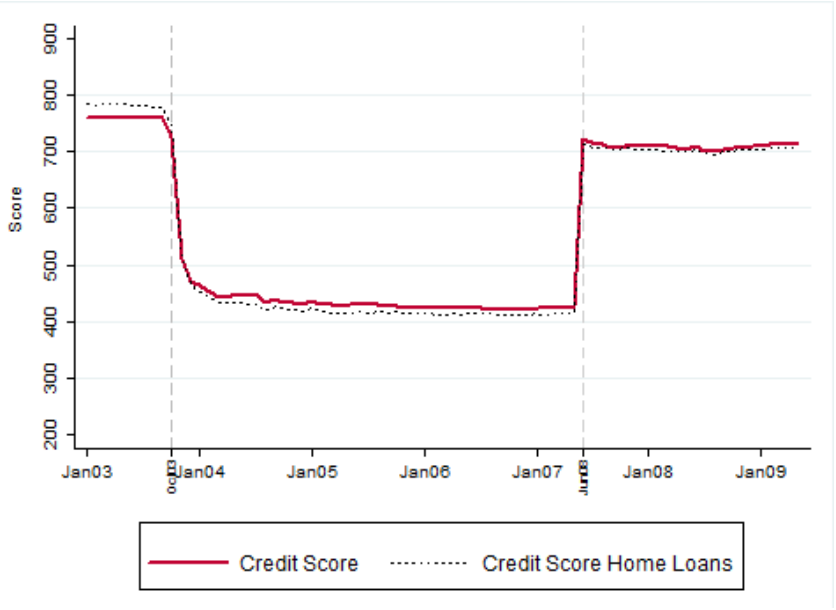
The majority of mortgage applicants are existing customers with the bank (only 11 percent are new customers), and have been clients of the bank on average for 9 years, which suggests that the bank has good credit and financial history of its clients. However, the bank extends its data collection on borrower credit history and credit risk. It reports a credit score for each mortgage borrower; although the construction of the credit scores is not revealed, we understand that it is externally assessed.[34] On a scale from 0 to 1,000, the credit score is on average 565. Figure 3.8 reveals that the credit score distribution is bimodal; this is explained by structural breaks in the trend over time as reflected in Figure 3.9. Average credit scores for successful mortgages fell from around 750 points to around 450 points between October and November 2003, and remained around 420 points for more than 3 years. However, with the advent of the international financial crisis, average scores rose to around 700 points in June 2007.

FIGURE 3.8: Credit Scores, Histograms.



[34] Possibly the credit score is constructed following Credit Reference Association of Australia (CRAA) standards. However, unlike the U.S. where the FICO score is a uniform credit score universally used across banks and financial institutions, Australia lacks a homogeneous credit measure for comparison purposes. An application score is also reported, which we suspect is internally determined by information collected by the bank. However, we also have little information on the construction of this score.

FIGURE 3.9: Average Monthly Credit Scores, Over Time.



Over half of applicants had bankruptcy checks and searches done at application time.[35] While 86 percent of applicants have no defaults recorded by the CRAA, another 12 percent have no record or their record was not checked; only 2 percent of applicants have one or more previous recorded defaults.[36]

A small proportion of all borrowers (5 percent) are first-time home buyers (FHBs) in the sample period; of these, 90 percent are owner-occupiers – only 3 percent of FHBs are investors. This proportion is small relative to national figures reported by the ABS, as shown in Figure 3.10. However, when inspecting only the sub-sample of owner-occupiers, FHBs represent 10 percent of all home-owner mortgagees.

3.2.3 Property under mortgage contract

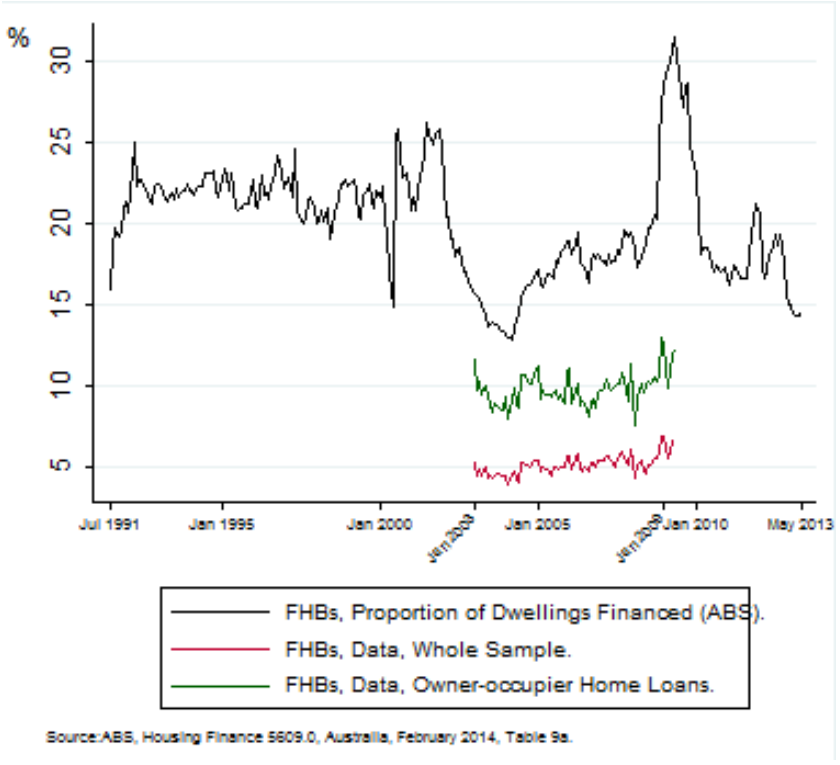
Almost half of applications report the type of property under the mortgage contract. These records reveal that 91 percent are existing houses or units; newly built (0.7 percent) or to be built (6.6 percent) houses, together with vacant land, represent very small proportions.[37]

[35] While 20 percent of them had a search on the month before application, 48 percent had a search covering six months before application, and 65 percent had a search covering a year before application.

[36] Only 35 applicants have a positive fraud check result. The bank also undertakes current and previous address, employment and driver license verifications.

[37] Although there are variables for number of bedrooms and type of construction (solid brick, brick veneer, weatherboard), these variables are not informative as there are too many missing observations.

FIGURE 3.10: Proportion of First-time Home Buyers (FHBs).



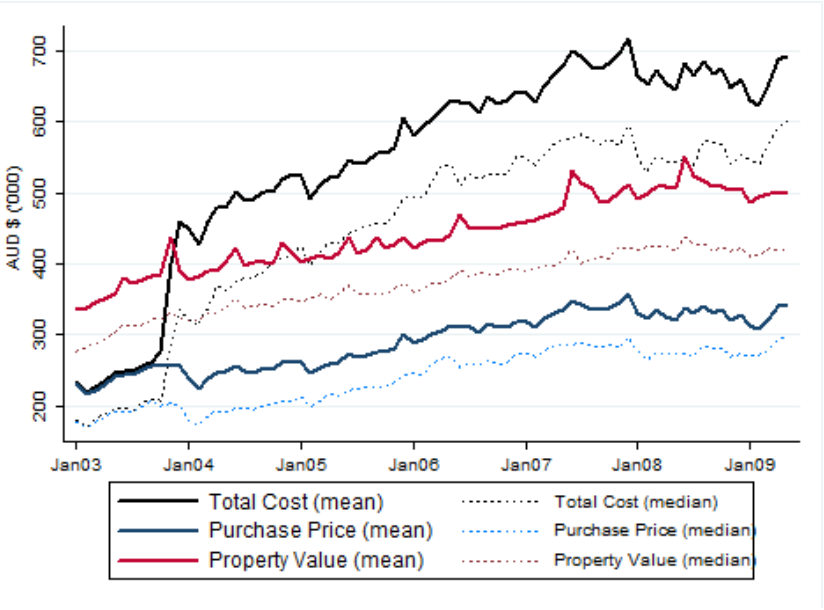
The postcodes for the mortgaged property and for the applicant's residence are provided. The postcode for the property is different to the borrower's postcode for 29 percent of applicants, however only 5 percent correspond to a different state.

Figure 3.11 reports the cost and price of the property under the mortgage contract. Although over half of applications do not report the purchase price at the final stage of the mortgage contract, the average purchase price is AUD $288,061, and the average total property cost reported – which includes purchase price and additional costs – is AUD $537,902. The lender obtains a valuation for the property before finalizing the mortgage contract; the average property value is AUD $443,232.

3.3 Data cleaning

Data management for this extensive and rich dataset was rigorous. Data de-codification and interpretation was laborious. In this section I specify the cleaning process of the raw database on mortgage applications, while in the following section I describe the characteristics of the remaining cleaned data available for this study.

FIGURE 3.11: Property under mortgage.



Overall, 76,205 observations were deleted from the raw sample. The misreported observations were related to mortgage costs, personal demographic characteristics of the applicants, and their financial situation and repayment capacity.

Some 3,692 observations were deleted due to errors related to mortgage costs and terms. Some applications had no information on the associated mortgage interest rate, and others reported a loan amount under AUD $1,000.[38] Also, observations from applications with LTVs under 1 percent and an extreme LTV value of 325 percent were deleted.

Additionally, 9,976 observations were deleted due to misreporting applicants' demographic characteristics. Some applicants appeared to be aged under 17 years old or over 98 years old.[39] Some applicants do not specify their gender or marital status, and do not report the years spent at the current address.[40]

Most importantly, 34,049 observations were deleted due to misreporting applicants' financial position. Less than 2 percent of applicants report no income or a monthly income

[38]The minimum loan size for a mortgage is generally around AUD $20,000-50,000. The dataset contains 19 percent applications with loan sizes under AUD $50,000, however, these observations are kept as some of them may be a result of mortgage refinancing or supplementary loans.

[39]A remaining 135 borrowers are aged 90 years old or over, however only 6 percent of the sample represent applicants over 60 years old.

[40]Some applicants do not report the time spent at their previous address (113), nor the time at their current and previous employments (6,232 and 896 respectively).

lower than AUD $600. According to the ABS,[41] the mean equivalised private income per week for the bottom 10th income percentile of the population is AUD $137 (AUD $548 monthly), the mean equivalised weekly disposable income is AUD $430 (AUD $1,720 monthly), and the mean equivalised disposable income plus social transfers in kind is AUD $721 (AUD $2,884 monthly). I selected a cut-off value of AUD $600 because the database reflects a discontinuity around that value. Although this group of applicants may be part of a non-conforming mortgage population, this is ignored for the purpose of this work. Similarly, some applicants report no monthly expenditures or total monthly expenditures under AUD $10 or over AUD $1,000,000; these values were replaced by the bank's calculations of total monthly expenditure in most cases, except for few cases which were deleted.[42] Additional observations were deleted for monthly personal living expenses and monthly non-durable expenditure lower than AUD $10 but different from zero. Applications with net wealth, liquid assets and short term liabilities under AUD $100 but different from zero were also deleted.

Finally, given the disperse distributions, I deleted 1 percent of the bottom and top tails of the distribution for net wealth, and 1 percent of the top tail of the distributions of liquid assets and short term liabilities – a total of 21,903 observations. A small group of home loans were designed for the bank's employees; this sub-sample of 906 observations were deleted. Similarly, some mortgage products were not clearly identified, for which 5,679 observations were deleted.

The cleaning process left on average 15,167 mortgage applications per month during January 2003 to May 2009. However, during October 2003 only 4,812 mortgage applications are left in the database, probably due to some internal recording issue at the bank. I control for this in our estimations by checking the robustness of ignoring the data before October 2003 or including it, without major discrepancies.

[41] See ABS, Household Income and Income Distribution 6523.0, Australia, 2011-2012. Equivalised total household income as reported by the ABS is household income adjusted by the application of an equivalence scale to facilitate comparison of income levels between households of differing size and composition, reflecting that a larger household would normally need more income than a smaller household to achieve the same standard of living. Equivalised total household income is derived by calculating an equivalence factor according to the 'modified OECD' equivalence scale, and then dividing income by the factor. The equivalence factor is built up by allocating points to each person in a household (1 point to the first adult, 0.5 points to each additional person who is 15 years and over, and 0.3 to each child under the age of 15) and then summing the equivalence points of all household members. Equivalised total household income can be viewed as an indicator of the economic resources available to a standardised household; see http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2901.0Chapter31502011.

[42] These exemptions are due to extreme values in total monthly expenditure as calculated by the bank.

3.4 Owner-occupied mortgage products

Previous sections presented an overview of the raw dataset in this study, and summarized the cleaning process applied. This section describes the cleaned sub-sample of owner-occupier mortgage applications, which will be used throughout the following chapters of this thesis. For comparison purposes, Section 3.5 describes the cleaned sub-sample of residential investment property loans (RIPLs); although that dataset is left for future work.

Over half of the mortgage applications in the database are owner-occupier home loans, which are the main focus of this thesis. Owner-occupier home loans are the most popular mortgages taken in the data sample. Owner-occupier borrowers can choose between several home loan products; in the sample, the majority (56 percent) choose variable-rate loans (VRMs), but other options available are discounted variable-rate loans – or 'honeymoon' mortgages (HMs) – (23 percent), short-term fixed-rate loans (SFRMs, 16 percent) and home equity loans (HEs, 5 percent) as reported in Table 3.1.

Owner-occupier home loan applicants, intending to purchase a residential home, are an heterogeneous group, however they are distinctive relative to borrowers taking mortgages for alternative purposes such as investments or refinancing. Table 3.3 presents applicants' characteristics across owner-occupier home loan products offered.

The mean owner-occupier applicant is 41 years old; applicants choosing fixed-rate mortgages are slightly younger, and those taking home equity loans are on average 47 years old.[43] Females represent around a third of all owner-occupier applicants, and only a quarter for owner-occupiers taking home equity loans; the proportion of females taking variable-rate mortgages decreases during the sample period. Over two thirds of owner-occupier applicants are married or in a de facto relationship.[44] Among all owner-occupier applicants, 58 percent have no dependents (the proportion is larger for home equity loan applicants). For those who have dependents, they tend to have on average one 6-year-old child (7-year-old for home equity applicants); the number of dependents

[43] Discounted variable-rate owner-occupier applicants mean age increases over the sample period, from 38 to 40 years old.

[44] For the rest of this thesis the dummy for 'Married' includes married couples and couples in a de-facto relationship.

TABLE 3.3: Owner-occupier Home Loan Borrower Characteristics across Mortgage Products

	VRM	SFRM	HM	HE	Total
Applicant's age (years)	41.1	38.6	40.1	46.6	40.7
	(10.6)	(10.2)	(11.1)	(10.8)	(10.8)
Proportion of females	0.30	0.34	0.34	0.25	0.31
	(0.5)	(0.5)	(0.5)	(0.4)	(0.5)
Proportion of married	0.70	0.65	0.64	0.78	0.68
	(0.5)	(0.5)	(0.5)	(0.4)	(0.5)
Number of dependents	0.8	0.8	0.8	0.7	0.8
	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)
Age of youngest dependent (years)	6.5	6.0	6.5	7.4	6.5
	(5.1)	(4.8)	(4.9)	(5.2)	(5.0)
Age of oldest dependent (years)	9.2	8.6	9.2	10.1	9.1
	(5.6)	(5.4)	(5.3)	(5.4)	(5.5)
Time at previous address (years)	1.8	2.1	2.0	1.3	1.9
	(4.3)	(4.6)	(4.6)	(3.8)	(4.4)
Time at current address (years)	6.3	5.3	6.3	8.2	6.2
	(6.9)	(6.2)	(6.8)	(7.7)	(6.8)
Time at previous employment (years)	1.3	1.2	1.3	0.9	1.2
	(3.4)	(3.1)	(3.2)	(3.2)	(3.3)
Time at current employment (years)	6.6	5.7	5.9	8.9	6.4
	(7.0)	(6.4)	(6.6)	(8.4)	(6.9)
Number of applicants	1.8	1.7	1.7	1.8	1.8
	(0.8)	(0.8)	(0.8)	(0.8)	(0.8)
Proportion of co-borrowers	0.72	0.67	0.62	0.69	0.68
	(0.5)	(0.5)	(0.5)	(0.4)	(0.4)
Proportion of first-time home buyers	0.08	0.11	0.11	0.01	0.09
	(0.3)	(0.3)	(0.3)	(0.1)	(0.3)
Proportion of existing customers	0.87	0.85	0.82	0.93	0.86
	(0.3)	(0.4)	(0.4)	(0.3)	(0.4)
Time with the Bank (years)	9.0	7.8	7.9	11.4	8.6
	(7.0)	(6.7)	(6.9)	(7.7)	(7.0)
Total observations:	321,057	88,761	133,207	27,614	570,639

Means and (standard deviations). Jan2003-May2009. Prices are in real terms 2011/2012.

slightly decreases over time, particularly at the end of the sample. Therefore, owner-occupiers are well represented in the population of mortgages of this study, as compared to Section 3.2.2.

Applicants are required to report the time spent at previous and current addresses and employments to assess their mobility and repayment capacity. Owner-occupier applicants spent on average 2 years at their previous address and 6 years at their current address; the years spent at the previous address decrease over the sample period. They spent a similar amount of time at their previous and current employments.[45] In particular, while the time at current address for owner occupiers taking a discounted variable-rate mortgage increases over time, the years spent at previous and current employments slightly decreases over the sample period.

[45]However, the correlation between these two variables – current employment and current address, or previous employment and previous address – is only around 0.25 and 0.08 respectively.

Most owner-occupier applicants submit a mortgage application with a co-applicant, particularly when applying for VRMs. First-time home buyers (FHBs) represent 9 percent of the owner-occupier sample. Figure 3.12 reports the proportion of FHBs across owner-occupier home loan products. It shows that owner-occupier SFRM and HM applications have a higher proportion of FHBs than VRMs; FHBs are unusual for HEs. Additionally, over 80 of owner-occupier applicants are existing customers to the bank, and have been clients of the bank for 8.5 years on average. The proportion of existing customers and the years with the bank increased over time, particularly by the end of the sample period.

FIGURE 3.12: Owner-occupier First-time Home Buyers (FHBs)

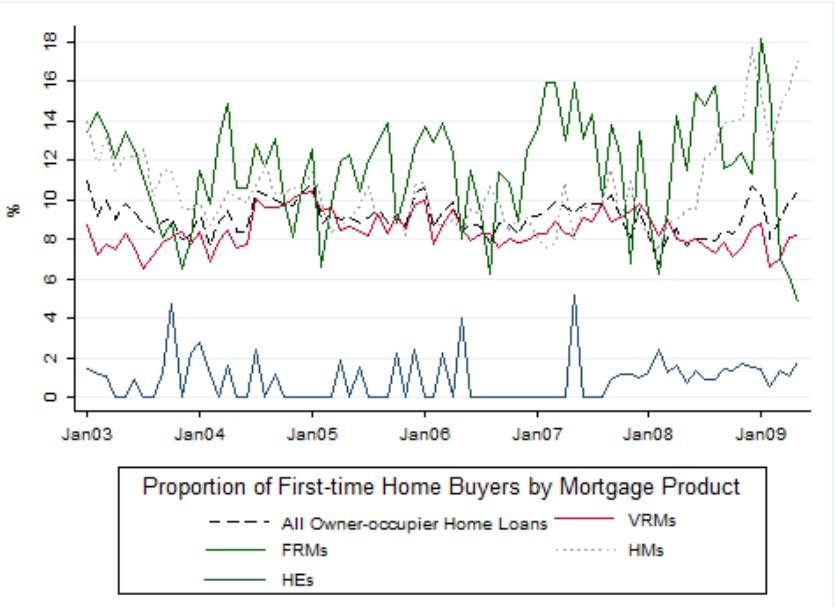


Table 3.4 presents an overview of the financial position of owner-occupier borrowers at application across the different mortgage products. Owner-occupier applicants spend on average AUD $1,054 per month on loan payments (such as credit cards, personal loans and lines of credit), and AUD $1,610 on monthly mortgage payments on average.[46] Borrowers taking HEs have larger non-mortgage loan payments relative to other mortgage holders, as they make irregular and infrequent mortgage repayments given the characteristics of this type of mortgage contract. The monthly expenditure on non-durable goods is on average AUD $1,586, which is mainly determined by monthly personal living expenses. Borrowers taking HEs and VRMs have higher monthly consumption expenses

[46]The median monthly loan payment is AUD $375, while the median monthly mortgage payment is AUD $1,413.

than borrowers taking SFRMs and HMs. Overall, owner-occupier borrowers report an average AUD $2,863 on monthly total expenditure, however the lender calculates this monthly expenditure to be almost double, on average AUD $4,982.

TABLE 3.4: Home Loan Borrower Financial Position across Mortgage Products

	VRM	SFRM	HM	HE	Total
Monthly loan payments (excl. mortgage)	$1,139	$1,036	$596	$2,337	$1,054
	(1,839)	(1,579)	(1,080)	(2,924)	(1,764)
Monthly mortgage payments	$1,868	$1,603	$1,322	$27.46	$1,610
	(1,566)	(892)	(833)	(224)	(1,359)
Monthly non-durable expenditure	$1,619	$1,543	$1,498	$1,763	$1,586
	(790)	(691)	(761)	(963)	(781)
Monthly personal living expenses	$1,584	$1,533	$1,446	$1,735	$1,551
	(667)	(595)	(565)	(893)	(651)
Monthly total expenses	$3,002	$2,693	$2,366	$4,188	$2,863
	(2,667)	(2,149)	(2,212)	(3,338)	(2,561)
Monthly total expenses (Bank)	$5,380	$4,773	$3,954	$6,119	$4,982
	(4,929)	(2,365)	(1,970)	(3,637)	(4,061)
Net monthly income	$7,074	$6,292	$5,319	$8,395	$6,606
	(4,011)	(3,426)	(2,667)	(5,163)	(3,809)
Gross monthly income	$9,320	$8,183	$6,645	$11,127	$8,606
	(6,371)	(5,390)	(4,255)	(8,111)	(6,024)
Uncommitted monthly income	$2,878	$2,617	$2,338	$4,074	$2,769
	(2,639)	(2,158)	(1,597)	(3,259)	(2,426)
Uncommitted monthly income (Bank)	$1,694	$1,559	$1,364	$2,277	$1,624
	(4,670)	(2,239)	(2,215)	(3,266)	(3,841)
Short-term liabilities	$6,024	$5,285	$4,945	$19,640	$6,316
	(16,612)	(15,710)	(13,553)	(41,548)	(18,145)
Total liabilities	$203,796	$195,822	$136,971	$308,044	$192,001
	(243,825)	(218,477)	(153,039)	(343,819)	(231,300)
Liquid assets	$73,563	$56,605	$42,468	$113,699	$65,609
	(117,561)	(97,792)	(80,217)	(149,381)	(110,138)
Total property value^{+}	$522,864	$433,235	$369,301	$913,808	$491,994
	(489,378)	(418,824)	(345,360)	(676,992)	(474,601)
Total value of shares *	$48,671	$48,827	$38,656	$96,289	$46,913
	(123,132)	(116,253)	(117,887)	(210,510)	(123,657)
Total assets	$735,493	$607,548	$517,113	$1,187,648	$686,495
	(603,227)	(505,993)	(422,876)	(798,769)	(581,673)
Net wealth	$531,697	$411,727	$380,142	$879,604	$494,494
	(486,046)	(395,246)	(362,526)	(650,885)	(469,540)
Total observations	321,057	88,761	133,207	27,614	570,639

Means and (standard deviations). Jan2003-May2009. Prices are in real terms 2011/2012.
$^{+}$ Only 3.6 percent of owner-occupier applicants report to own shares.
* Around 16 percent of owner-occupier applicants do not report property value.

Owner-occupier borrowers earn on average AUD $8,606 on gross monthly income (AUD $103,272 annually), of which AUD $6,606 is net monthly income. Borrowers applying for VRMs have average incomes 12 percent larger than those taking SFRMs. UMI, as reported by the owner-occupier applicant, is on average AUD $2,769; the lender estimates UMI to be on average AUD $1,624.

Assets and liabilities distributions for owner-occupier applicants have large dispersion, despite deleting top and bottom tail percentiles. Short-term liabilities for owner-occupier

applicants are on average AUD $6,316, while the median is AUD $1,271. Total liabilities for owner-occupiers at application time are on average AUD $192,001, with a median of AUD $137,848. Liquid assets are on average AUD $65,609 (with a median of AUD $22,989), which suggests that applicants can afford a mortgage deposit with genuine savings. Some owner-occupier applicants also report the value of properties and shares; the average property value is AUD $491,994 (with a median of AUD $397,653), while the average value of shares is AUD $46,913 (with a median of AUD $12,563). The average total assets are $686,495, and the median is $541,872. Overall, applicants net wealth is $494,494, with a median of $364,652.

Clearly, owner-occupier borrowers applying for HEs seem distinct from those applying for more traditional home loans; they are older and have higher income and expenditure, but most importantly, they hold more wealth. This proposition is tested in the following chapter when we build borrower typologies. Individuals applying for a VRM have a stronger financial position than those applying for SFRMs and, specially, HMs.

Finally, Table 3.5 summarizes mortgage costs and characteristics of owner-occupier mortgage contracts. Owner-occupier borrowers apply for loans of AUD $245,949 on average, with a loan life of approximately 27 years. Larger loan sizes are associated with VRMs. Interest rates are highest for HEs, and lowest, as expected, for HMs. Monthly repayments are on average AUD $1,539. Bank fees are around AUD $800, while the applicant contribution at the final stage of the contract averages AUD $147,333 – with a median of AUD $85,461. The average credit score is 562; HEs require higher credit scores, of on average 700. Mortgage repayments represent 14 percent of owner-occupier income on average (PTIR) – the median PTIR is 8 percent. PTIR are higher for HEs, probably because HE borrowers face higher interest rates. Additionally, 45 percent of owner-occupier income covers all of their debt-servicing (DSR). The LTV for owner-occupier applicants is on average 62 percent; LTVs are lower for HEs and VRMs. The average property under the mortgage has been purchased for a price of AUD $361,336, however it is valued at AUD $439,102.

TABLE 3.5: Home Loan Costs and Characteristics

	VRM	SFRM	HM	HE	Total
Loan size	$274,461	$225,195	$198,038	$212,275	$245,949
	(200,140)	(126,220)	(110,089)	(189,864)	(175,223)
Life of loan (term in years)	26.8	27.6	27.6	27.6	27.1
	(6.7)	(4.7)	(5.0)	(6.8)	(6.0)
Interest rate	7.13%	7.34%	6.63%	7.82%	7.08%
	(0.8)	(0.8)	(1.0)	(1.2)	(0.9)
Monthly repayment	$1,801	$1,522	$1,246	$0	$1,539
	(1,435)	(898)	(772)	(0)	(1,262)
Bank fees	$834	$792	$719	$874	$802
	(197)	(233)	(132)	(211)	(198)
Total contribution*	$163,956	$146,439	$103,764	$241,228	$147,333
	(191,973)	(182,131)	(124,823)	(224,858)	(178,773)
Credit score	558	535	561	700	562
	(183)	(179)	(196)	(128)	(186)
Payment-to-income ratio (PTIR)	14.4%	14.5%	10.5%	25.3%	14.1%
	(16.2)	(14.9)	(13.6)	(20.9)	(16.0)
Debt service-to-income ratio (DSR)	45.5%	46.3%	40.2%	48.7%	44.5%
	(18.6)	(15.7)	(14.9)	(19.1)	(17.6)
Loan-to-value ratio (LTV)	61.6%	66.2%	63.0%	56.2%	62.4%
	(21.9)	(20.2)	(20.8)	(19.7)	(21.4)
Purchase price+	$410,658	$319,975	$270,755	$280,355	$361,336
	(292,382)	(214,746)	(162,039)	(255,853)	(262,245)
Property valuation	$469,918	$418,390	$347,704	$588,896	$439,102
	(290,087)	(246,179)	(180,740)	(354,951)	(272,248)
Total observations	321,057	88,761	133,207	27,614	570,639

Means and (standard deviations). Jan2003-May2009. Prices are in real terms 2011/2012.
* 24 percent of owner-occupier applicants report their total contributions.
+ 38 percent of owner-occupier applicants report the property purchase price.

3.5 Residential investment property loans

Residential investment property loans (RIPLs) are mortgages destined for investors purchasing an income producing property; 21 percent of the applicants in the database are residential investors. Residential investors in Australia can claim a tax deduction for any expenses incurred in running the income producing property, including loan interest. In this way, many Australian real estate investors are 'negatively geared'. This tax advantage distinguishes residential property investors from owner-occupier residential buyers. Tables 3.6-3.8 reflect these differences when compared with Tables 3.3-3.5.

Residential investors can choose between fixed- and variable-rate mortgages;[47] they can also access discounted variable-rate mortgages, but not the home equity option. Over

[47]Residential mortgagees can also opt for 'split loans', where a proportion of their debt has a variable interest rate, and the remaining is set with a fixed rate. They may also access interest-only or interest-in-advance loans more readily than homeowners. We are not able to distinguish these types of loans in the database.

half (55 percent) of RIPL applicants choose VRMs, an additional 20 percent choose HMs, and 25 percent choose SFRMs.

Table 3.6 shows RIPLs' characteristics across mortgage products. RIPL borrowers are on average older than owner-occupier borrowers, with an average age of 43 years. Over a quarter of investors are women (27 percent). Although 72 percent of investors are married, 66 percent have no dependents; when present, the youngest dependent is on average 7 years old, and the oldest dependent is 10 years old.

TABLE 3.6: Residential Investment Property Loan (RIPL) Borrower Characteristics across Mortgage Products

	VRM	SFRM	HM	Total
Applicant's age (years)	43.1	43.3	43.1	43.1
	(10.5)	(10.4)	(11.1)	(10.6)
Proportion of females	0.26	0.28	0.28	0.27
	(0.4)	(0.5)	(0.5)	(0.4)
Proportion of Married	0.72	0.73	0.70	0.72
	(0.5)	(0.4)	(0.5)	(0.5)
Number of dependents	0.6	0.7	0.6	0.7
	(1.0)	(1.0)	(1.0)	(1.0)
Age of youngest dependent (years)	7.2	7.5	7.0	7.3
	(5.3)	(5.4)	(5.3)	(5.3)
Age of oldest dependent (years)	9.8	10.0	10.1	9.9
	(5.6)	(5.7)	(5.6)	(5.7)
Time at previous address (years)	1.6	1.6	1.7	1.6
	(4.1)	(4.2)	(4.2)	(4.1)
Time at current address (years)	7.3	7.1	7.5	7.3
	(7.4)	(7.3)	(7.8)	(7.5)
Time at previous employment (years)	1.1	1.1	1.1	1.1
	(3.2)	(3.4)	(3.3)	(3.3)
Time at current employment (years)	8.0	8.2	7.8	8.0
	(7.7)	(7.9)	(7.7)	(7.8)
Number of applicants	1.8	1.7	1.9	1.8
	(1.2)	(1.1)	(1.3)	(1.2)
Proportion of co-borrowers	0.63	0.59	0.61	0.62
	(0.5)	(0.5)	(0.5)	(0.5)
Proportion of first-time home buyers	0.01	0.01	0.01	0.01
	(0.1)	(0.1)	(0.1)	(0.1)
Proportion of existing customers	0.90	0.91	0.87	0.90
	(0.3)	(0.3)	(0.3)	(0.3)
Time with the Bank (years)	9.7	9.8	9.0	9.6
	(7.0)	(7.0)	(7.0)	(7.0)
Total observations	124,083	56,736	43,950	224,769

Means and (standard deviations). Jan2003-May2009. Prices are in real terms 2011/2012.

RIPL borrowers appear to have spent more time at their current address and employment relative to home-owner applicants. RIPL borrowers have spent on average 2 years in their previous address, and 7 years at their current address. Similarly, they have spent on average 1 year and 8 years in their previous and current employment respectively.

Most applications (62 percent) are submitted by joint applicants. RIPL applicants are not first-time home buyers. The FHB status is assigned to access the first home owner grant (FHOG) provided by the government. One of the main requisites to be eligible for a FHOG is to reside in the mortgaged property as the principal place of residence for a continuous period of 6 months within one year of the property being purchased. For this reason RIPL borrowers tend not to qualify for FHOG.[48] The vast majority of residential investors have been existing customers of the bank for 9.5 years on average.

Table 3.7 presents RIPLs borrowers' financial position and repayment capacity. RIPL applicants have larger monthly loan payments than owner-occupiers. Monthly loan payments (excluding mortgages payments) are on average 2.6 times larger for RIPLs relative to owner-occupier borrowers. RIPLs borrowers' monthly mortgage payments are on average AUD $2,335, with a median of AUD $1,702. Although monthly non-durable and personal living expenses are similar for both groups of borrowers, RIPLs have slightly larger total monthly expenses. RIPLs borrowers report on average AUD $5,232 on monthly total expenditure (with a median of AUD $3,813), however the bank's calculation is on average AUD $7,292 (with a median of AUD $6,183). An interesting distinction between owner-occupier home loans and RIPLs is that borrowers taking SFRM RIPLs have higher spending patterns, while owner-occupiers taking VRMs have higher spending patterns.

RIPL borrowers' monthly income is 39 percent higher than owner-occupiers' income. The average net monthly income for RIPLs is AUD $9,201, and the average gross income is AUD $11,994. UMI, as reported by the RIPL applicant, is AUD $2,159 on average; the bank's calculations assess AUD $250 less UMI n average that what the RIPL applicant reports. Interestingly, UMI for borrowers taking SFRM RIPLs is negative on average, suggesting that their income does not cover all their financial commitments – the median value is AUD $1,837. However, according to the lender's calculations, RIPL borrowers with SFRMs average UMI is AUD $1,977.

The financial position of RIPL applicants is almost two times higher than that of owner-occupier home loan applicants. Total liabilities at time of application are on average AUD $381,530 for RIPL borrowers, 79 percent higher than for owner-occupier home loan borrowers. RIPL borrowers' total assets are on average AUD $1,277,780, which is

[48] However, the database reveals 1,478 applicants (0.7 percent of the sample) who report to be FHBs.

TABLE 3.7: Residential Investment Property Loan (RIPL) Borrower Financial Position across Mortgage Products

	VRM	SFRM	HM	Total
Monthly loan payments (excl. mortgage)	$2,868	$ 3,080	$2,022	$2,756
	(3,613)	(3,669)	(2,560)	(3,468)
Monthly mortgage payments	$2,202	$3,279	$1,491	$2,335
	(1,641)	(6,523)	(1,078)	(3,582)
Monthly non-durable expenditure	$1,645	$1,659	$1,512	$1,623
	(1,066)	(1,008)	(911)	(1,024)
Monthly personal living expenses	$1,637	$1,626	$1,479	$1,604
	(887)	(894)	(722)	(861)
Monthly total expenses	$5,260	$5,430	$4,901	$5,232
	(4,985)	(4,871)	(4,966)	(4,956)
Monthly total expenses (Bank)	$7,746	$7,505	$5,734	$7,292
	(6,179)	(5,399)	(3,334)	(5,587)
Net monthly income	$9,693	$9,482	$7,449	$9,201
	(6,099)	(5,938)	(4,249)	(5,807)
Gross monthly income	$12,726	$12,472	$9,309	$11,994
	(9,134)	(8,988)	(6,343)	(8,722)
Uncommitted monthly income	$3,104	- $223	$2,565	$2,159
	(3,185)	(9,452)	(2,224)	(5,574)
Uncommitted monthly income (Bank)	$1,947	$1,977	$1,714	$1,909
	(5,132)	(4,123)	(2,598)	(4,490)
Short-term liabilities	$11,402	$12,438	$9,474	$11,286
	(38,233)	(39,559)	(32,932)	(37,616)
Total liabilities	$391,344	$438,619	$280,127	$381,530
	(454,001)	(469,771)	(329,810)	(440,052)
Liquid assets	$134,719	$140,220	$86.869	$126,751
	(202,467)	(209,506)	(147,490)	(195,843)
Total property value^{+}	$1,093,496	$1,109,711	$846,076	$1,050,228
	(934,757)	(941,714)	(751,299)	(909,802)
Total value of shares*	$78,521	$102,877	$63,429	$79,364
	(195,858)	(258,882)	(160,450)	(202,773)
Total assets	$1,324,979	$1,383,863	$1,007,578	$1,277,780
	(1,164,701)	(1,164,901)	(934,699)	(1,131,621)
Net wealth	$933,635	$945,244	$727,451	$896,249
	(923,339)	(905,077)	(770,283)	(894,641)
Total obervations	124,083	56,736	43,950	224,769

Means and (standard deviations). Jan2003-May2009. Prices are in real terms 2011/2012.
$^{+}$ Only 6.2 percent of RIPLs applicants report to own shares.
* Only 8.3 percent of RIPLs applicants do not report property value.

86 percent higher than for owner-occupiers. On average, net wealth for RIPLs is AUD $896,249, while for owner-occupier home loans it is AUD $494,494. RIPL applicants taking SFRMs have higher net wealth than those taking VRMs. In the case of RIPLs, although borrowers may be able to afford larger early repayments, they have little incentives to repay their debt sooner as higher interest repayments are deducted from taxable income in negative gearing. RIPL borrowers hold a larger proportion of SFRMs.

Finally, Table 3.8 reports RIPLs costs and characteristics across mortgage products. Although the loan amount taken by RIPL applicants is 20 percent larger than that for owner-occupier loans, they seem to have on average lower associated interest rates and

higher bank fees. The average RIPL borrower takes a loan of AUD $298,818 for a term of 28 years, with associated banks fees of AUD $865. Monthly mortgage repayments are also around 15 percent higher for RIPLs relative to owner-occupier home loans, except for SFRMs; average monthly mortgage repayments are AUD $2,684. Monthly repayments for SFRMs in RIPLs are on average 2.23 times larger than those for owner-occupier home loans, even though larger loans are associated with VRMs.

Table 3.8: Residential Investment Property Loans (RIPL) Costs and Characteristics

	VRM	SFRM	HM	Total
Loan size	$332,607	$279,615	$228,211	$298,818
	(237,714)	(180,602)	(143,108)	(212,440)
Life of loan (term in years)	28.5	27.8	28.4	28.3
	(4.2)	(4.3)	(3.9)	(4.2)
Interest rate	7.06%	7.18%	6.58%	7.00%
	(0.9)	(0.8)	(0.9)	(0.9)
Monthly repayment	$2,116	$4,919	$1,401	$2,684
	(1,581)	(9,522)	(949)	(5,122)
Bank fees	$883	$865	$813	$865
	(204)	(249)	(197)	(217)
Total contribution*	$112,714	$98,261	$75,880	$101,690
	(149,720)	(135,971)	(96,432)	(137,680)
Credit score	572	559	567	568
	(176)	(171)	(181)	(176)
Payment-to-income ratio (PTIR)	26.7%	29.4%	24.6%	27.0%
	(20.3)	(19.7)	(19.9)	(20.1)
Debt service-to income ratio (DSR)	55.8%	55.6%	48.2%	54.2%
	(19.6)	(18.6)	(18.2)	(19.3)
Loan-to-value ratio (LTV)	64.3%	63.8%	63.7%	64.1%
	(18.4)	(18.2)	(18.8)	(18.4)
Purchase price+	$388,949	$326,527	$260,793	$348,967
	(266,754)	(206,710)	(159,550)	(241,279)
Property valuation	$498,194	$459,435	$368,162	$462,981
	(345,322)	(318,338)	(232,230)	(323,107)
Total observations	124,083	56,736	43,950	224,769

Means and (standard deviations). Jan2003-May2009. Prices are in real terms 2011/2012.
* 22 percent of RIPLs applicants report their total contributions.
+ 49.6 percent of RIPLs applicants report the property purchase price.

Although net wealth and the size of the loan is on average larger for RIPLs relative to home loans, the average purchase price and valuation of the property are very similar across both types of mortgage purposes. The average property under a RIPL was purchased for AUD $438,967, but it is valued at AUD $462,981.

The average credit score is 568. PTIR is on average 27 percent, while DSR is 54 percent on average. LTVs are similar across mortgage products, with an average of 64 percent.

3.6 Other complementary data

Indicators of the economic environment and price expectations are presumed in the literature to help in the decision process of both borrowers and lenders. For this reason, individual loan-level data was complemented with data on market conditions by matching the corresponding monthly or quarterly macroeconomic indicators with the mortgage application date for each borrower.

All monetary values have been deflated by the quarterly consumer price index (CPI), and capital city CPIs were also used to check robustness.[49] Inflationary pressures have been taken into account by using the following series: national and capital city inflation rates,[50] and expected inflation, as measured by the Melbourne Institute survey on consumers' inflation expectations.[51]

The evolution of house prices is of particular interest in the study of housing finance and mortgage choice. House price inflation was obtained from the house price index, at both national and major-city levels.[52] The Westpac-Melbourne Institute Survey captures consumer sentiment on the housing market. We constructed the percentage change in this quarterly dwelling index to capture the change in the consumers' housing market sentiment. The index is available at a State level – data for the Territories (ACT and NT) are not available; state indexes have been matched with the corresponding state of the postcode of the property purchased.

As discussed in the previous chapter, the Australian government, together with the State governments, support first-time home buyers through a cash grant since July 2000, in some cases complemented with tax deductions. To account for this government support, we obtained from Dungey, Wells and Thompson [77] a quarterly series on net assistance to FHBs as a percentage of the median house price by State – Territories (ACT and NT) are not included.

[49] See RBA, Table G2: 'Consumer Price Index'. See also ABS, Consumer Price Index 6401.0, Australia, Table 5 'CPI: Groups, Index Numbers by Capital City'.
[50] See ABS, Consumer Price Index 6401.0, Australia, Tables 1 and 2 'CPI: All Groups, Index Numbers and Percentage Changes'.
[51] See RBA, Table G4: 'Other Price Indicators'.
[52] See ABS, House Price Indexes 6416.0: Eight Capital Cities.

Other monthly macroeconomic indicators considered are the national unemployment rate reported by the RBA and, for robustness purposes, the eight State and Territory gender unemployment rates matched by applicants' state postcode and gender.[53]

Market interest rates are particularly informative to lenders, as they are indicators of costs of funds, opportunity costs and market expectations. Moreover, sophisticated borrowers will follow the behavior of the interest rate reported by the central bank. Monthly data on market rates include: (1) the cash rate or interbank rate (a weighted average of the interest rates at which banks have borrowed and lent exchange settlement funds overnight), (2) the 30-day, 90-day, and 180-day bank accepted bill yields, and (3) 1-month, 3-month, and 6-month overnight indexed swaps (OIS) yields.[54] Long-term capital market yields were also accounted for by including the 3-year, 5-year, and 10-year Australian Government bond yields.[55]

Yield spreads between the 10-year (5-year or 3-year) Australian Government bond yield and the 90-day bank accepted bill yield were calculated to proxy for expectations on future interest rates behavior. Figure 3.13 reveals that between June 2006 and September 2008 Australia experienced an inverse yield curve. This is consistent with interest rates for fixed-rate mortgages being high relative to variable-rate mortgages, as already shown in the lower right panel of Figure 3.5.

To further capture the costs of funding for banks and their behavior over time, variables such as credit default swaps (CDS), term deposit rates and saving accounts rates were considered. The 5-year CDS spreads (AA-rated),[56] is a monthly series chosen to reflect the development of the securitization market in Australia during the sample period. However, as major banks in Australia source over half of their mortgage debt funding from deposits – see Deans and Stewart [64] – we include: quarterly series for banks' term deposits annual rates (for deposits of AUD $10,000 and maturities of 1-month, 3-month, 6-month, 1-year and 3-year), average term deposit rate across all terms, and average 'special' term deposit rate were sourced from the RBA.[57] Additionally, rates

[53] See ABS, Labour Force 6202.0, Australia. The eight States and Territories are New South Wales (NSW), Victoria (VIC), Australian Capital Territory (ACT), Queensland (QLD), South Australia (SA), Western Australia (WA), Tasmania (TAS) and Northern Territory (NT). Unemployment rates by gender have also been tested.

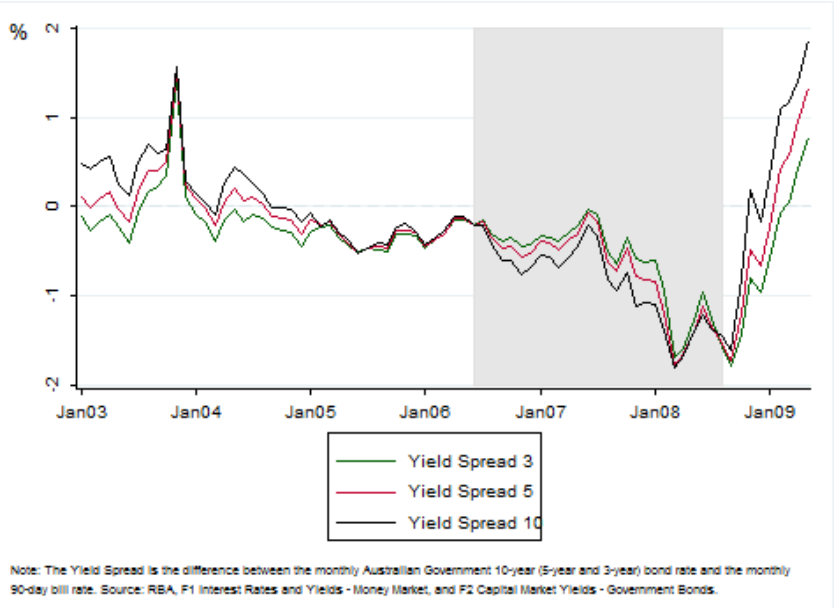
[54] See RBA, F1 Interest Rates and Yields - Money Market.

[55] See RBA, F2 Capital Market Yields - Government Bonds.

[56] See RBA, Table F.03:2 'Capital Market Yields and Spreads: Non-market instruments'. Sourced from the Australian Financial Markets Association (AMFA).

[57] See RBA, Table F4: 'Retail Deposit and Investment Rates'. These rates are an average for the five largest banks offered term deposit rates and 'special' rates, as determined by the RBA.

FIGURE 3.13: Yield Spreads.



for saving accounts of AUD $10,000, including on-line saving accounts, and banks' cash management accounts retail deposit rates were also considered.

Finally, market mortgage interest rates where considered as a reference for the interest rates provided in the database. Monthly housing loans standard variable, discounted variable, and 3-year fixed interest rates were used to reflect average mortgage market indicator lending rates.[58] Quarterly data on advertised housing loan rates for sixteen ADIs, including the four main banks, were also obtained from the RBA (not publicly available). These data provide an insight on the interest rate competition between mortgage lenders. Different types of advertised rates were distinguished, however only the standard variable rates for loans of AUD $250,000, and the standard 3-year fixed rates were used.

3.7 Conclusion

This chapter described the rich dataset that is the common denominator of the following three chapters in this thesis. The dataset in this study is unique in many ways. It is a bank-originated and verified data collection on mortgage applications that not only

[58] See RBA, F5 Indicator Lending Rates. Variable interest rates are also available for mortgage managers' housing loans.

cover owner-occupier home loans, but also mortgages with alternative purposes such as residential investment property loans, residential land loans, supplementary loans and home improvement loans. Few countries outside the U.S. have proprietary data of this nature available for research purposes. This rich dataset sheds light on the Australian housing finance market from a perspective frequently unaccessible, and offers an alternative to the frequently studied U.S. mortgage market. Many other countries share similar characteristics with the Australian housing finance market.

The dataset covers an interesting period of credit expansion in Australia, and around the world, that extended until the impact of the global financial crisis and the subsequent sovereign debt crisis in Europe. It is particularly relevant as the originator is one of the major mortgage players in the Australian market. It reveals detailed information collected and recorded during the mortgage contracting process.

First, this chapter provided an overview of the raw dataset, describing and presenting descriptive statistics for mortgage characteristics and borrower characteristics. Second, it explained the data decodification and cleaning process. Subsequently, it described the clean sub-samples of owner-occupier home loans and, for comparison purposes, residential investment property loans. The owner-occupier home loans are a good representation of the whole sample of mortgages in the dataset, and residential investors appear to be a very distinctive group. This thesis concentrates on owner-occupier home loans; residential investment home loans are left for future work. Lastly, the chapter explained the complementary data that was used to introduce market indicators into the analysis.

Despite its richness, the dataset has some short-comings. Although the data offer rich information during the mortgage contracting process, each individual mortgage is not followed through time, which inhibits a panel study. For this reason, I am not able to study mortgage termination (default or early prepayment) behavior, nor the evolution of the mortgage contract over time. Additionally, no information on borrower education, race or ethnicity is collected.[59] Despite this, the dataset proved to be rich and informative and enabled us to concentrate on understanding the mortgage application process,

[59]However, Yezer et al. [193] argue that race and ethnicity should not be included in mortgage choice studies. The lack of information on borrowers education is overcome by using occupation categories and some other proxies for financial literacy.

including mortgage choice, loan-to-value ratio and interest rate determination. This extensive dataset has revealed interesting loan-level insights of the mortgage market and confirmed some previous theoretical and empirical results.

Future work on mortgage choice using this dataset intends to combine this rich database on bank-generated mortgage applications to another extensive dataset on mortgages originated by mortgage brokers, and consider the reasons for any differences between loans with different originators.

The following chapters exploit the owner-occupier sample of the mortgage applications database for the period between January 2003 to August 2008. The sample period considered in the next chapters has been reduced to exclude the period of impact of the global financial crisis in Australia.

Chapter 4

Building Borrower Typologies in the Mortgage Market: Evidence from Australia

4.1 Introduction

Mortgage providers design a menu of mortgage products to cater for borrowers' preferences when financing housing through a home loan; see Dunn and Spatt [79] and Stanton and Wallace [174]. Considerations about borrowers' expected early prepayment and default characteristics allow lenders to price these contracts.[1] It is therefore important for the bank to identify relatively homogeneous groups of borrowers to more easily assess the risks and product needs associated with groups of borrowers.[2]

In this paper, we focus on the Australian housing credit market, and build typologies of borrowers based on their individual characteristics and the type of mortgage product they are taking. The Australian mortgage market is particularly suitable to observe mortgage transactions between lenders and borrowers because the underdeveloped securitization market and the absence of government-backed mortgage institutions motivate lenders to price mortgages by internalizing the mortgage risk held on-balance sheet.[3]

[1] See for example Santomero [163], Cunningham and Capone Jr [57] and Capone Jr and Cunningham [45].

[2] Gary-Bobo and Larribeau [94] argue, for example, that French lenders practice first-degree price discrimination, rather than self-selection or second-degree discrimination.

[3] See Oldfield and Santomero [149].

The mortgage market is dominated by four major domestic banks who hold the majority of the mortgage debt on-balance-sheet. For this reason, lenders in Australia need to assess accurately default and early prepayment risks to price mortgages suitably. In the U.S., banks more frequently transfer part of the mortgage risk to investors in the securitization market or through Government Sponsored Enterprises (GSEs). Building typologies in markets such as the U.S. might not be as informative as for the Australian market.

Banks are interested in customers' characteristics and risks, which allow them to apply a certain level of price discrimination in an asymmetric market. Borrowers self-select into mortgage contracts potentially pre-designed to match their preferences – related to the stage in the life-cycle, household income, level of wealth. However, the cost for banks to offer a wide menu of mortgage products that match individual borrower preferences is too high. It is more cost effective for the bank to price a particular mortgage product to an homogeneous group of borrowers; see Piskorski and Tchistyi [153].

The literature on mortgage product segmentation is limited, the vast majority has focused on the choice of institution for transaction banking services. Devlin [72] looks at the factors influencing home loan mortgage provider choice through survey data. They find higher income, and financially mature households are more price sensitive to interest rates and discounts, and are more likely to choose a mortgage provider based on product features and bank relationship; while low income households choose based on branch location, personal recommendations and professional advice. In contrast to these survey-based papers, the analysis of this thesis is based on the contracts which customers actually choose once they have arrived at the decision to take a mortgage with the bank.

Several studies have investigated how borrowers choose between mortgage products, mainly focusing on the U.S. mortgage market. Theoretical work finds that lower relative interest rates, borrower mobility, income growth, and default risk are important determinants of the mortgage product selection; see Baesel and Biger [19], Statman [175], Brueckner [33], Szerb [180] and Posey and Yavas [154]. Campbell and Cocco [43] find that risk-averse households with a large mortgage, risky income, high default cost, or low moving probability tend to prefer fixed-rate mortgages (FRMs). Meanwhile, households

with smaller housing equity relative to income, more stable income, lower risk aversion, more lenient treatment in bankruptcy, and a higher probability of moving prefer adjustable-rate mortgages (ARMs). The empirical evidence is however mixed. Dhillon et al. [73], Brueckner and Follain [34], Phillips and VanderHoff [152], Paiella and Pozzolo [150] and Vickery [183] conclude that the economic effect of borrower characteristics is insignificant in the mortgage product choice. However, Capone Jr and Cunningham [45], Sa-Aadu and Sirmans [162], Coulibaly and Li [54], Fortowsky et al. [88] and Cocco [50] underscore the relevance of borrower characteristics in mortgage choice.[4]

Some work has been done on newer suites of mortgage products[5] – such as home equity loans and discounted variable-rate mortgages. We contribute in this area by building Australian home loan borrower profiles for several mortgage contracts, including variable-rate mortgages (VRMs), short-term fixed-rate mortgages (SFRMs), home equity loans (HEs), and discounted variable-rate (or 'honeymoon') loans (HMs). Little work has been done in markets where the mortgage risk is shared mainly by borrowers and lenders. Securitization in Australia represents less than 8 percent of the composition of the major lenders' mortgage funding;[6] the major Australian banks source most of their funding from domestic deposits and wholesale debt. In this sense, most of the risks associated with mortgages are held on bank balance-sheets. Moreover, before the global financial crisis, Australian lenders did not receive any explicit Government guarantee. The large dataset used in this study, with 502,596 observations, is originated by one of the major Australian banks for the period January 2003 to August 2008, and reveals extensive information regarding product types and individual borrower characteristics.

This chapter has two main contributions. First, it explores the association between individual borrower characteristics and types of mortgage contracts through multiple correspondence analysis (MCA). Second, it constructs borrower typologies based on the

[4]Capone Jr and Cunningham [45] find that borrowers consider private expectations when deciding between holding adjustable- or fixed-rate loans. Sa-Aadu and Sirmans [162] differentiate mortgage contracts according to the frequency of the interest rate adjustments and find that young mobile borrowers who face positive income growth prefer contracts with short-term interest rate fixity. Coulibaly and Li [54] show that households with financial sophistication, high spending patterns and high mortgage balance-to-income ratio – proxying for financial constraint – are more likely to choose ARMs; risk averse borrowers who are not mobile and have high income volatility tend to choose FRMs. Fortowsky et al. [88] find that borrowers self-select into ARMs or other hybrid contracts when their probability of moving is high in the near future. Cocco [50] supports the relevance of education, occupation, income growth and income risk in the mortgage product choice.

[5]See Brueckner et al. [36], Cocco [50], LaCour-Little and Yang [128], Scanlon et al. [166], Fratantoni [91] and Shiller and Weiss [171].

[6]See RBA, 'Asset securitisation in Australia', Financial Stability Review, September 2004, http://www.rba.gov.au/publications/fsr/2004/sep/pdf/0904-1.pdf.

mortgage product chosen using cluster analysis. This work does not intend to identify heterogeneous groups endogenously, and does not intend to explain causality; a discrete choice model analysis on mortgage product choice on this same dataset is the subject of the next two chapters. Due to the discrete nature of the variables of interest, MCA is particularly appropriate to address this problem. MCA is a dimensionality reduction factor technique for categorical data. MCA has been applied in the social sciences by Bourdieu [30] and Bourdieu [31].[7] For a comparison of similar methodologies see Tenenhaus and Young [181].[8]

The MCA analysis reveals that single young applicants with low income and low wealth are distinctly different from the mean borrower. The results show that households with high income but low wealth are associated with standard VRMs and SFRMs, while households with high wealth but low income prefer products such as HMs and HEs. The MCA results are used to construct six borrower typologies: (1) young constrained households, with a large proportion of female main applicants, tend to prefer the initial discounts on the variable rates offered in HMs; (2) risk-averse, financially constrained young families opt for the short-term certainty of SFRMs; (3) senior borrowers prefer HEs; (4) mobile, first-time home buyers (FHBs) prefer SFRMs and HMs, suggesting they prefer certainty and are financially constrained; (5) settled families opt between HMs, SFRMs or VRMs; (6) low risk families take relatively more VRMs.

Borrowers selecting between a limited variety of mortgage products remain very heterogeneous within mortgage product since several of the typologies match more than one type of mortgage. SFRMs are the preferred contract for young constrained families, settled families, and mobile FHBs. HMs are attractive for young (female) households, for settled families and for mobile FHBs. VRMs are better suited for settled families and low risk families.

The remainder of this chapter is organized as follows. Section 4.2 describes the mortgage products in the Australian mortgage market. Section 4.3 presents the methodology.

[7]The MCA method is also used in sociology, development and health economics, marketing, and management; see for example: Fellenberg et al. [86], Guttman [104], Rouanet et al. [160], Spearman [172], Hirschfeld [111], Guttman [104], Burt [38], Lebart [135], Asselin and Anh [17], Kohn [124], Gatrell et al. [95], Carayol [46], Levy et al. [138], Baldini [20], Carayol and Matt [47], Hoffman and Franke [112], Mullet [147], Fernández-Aguirre et al. [87]

[8]See also Greenacre [102], Hayashi [108], Benzécri [23], Greenacre [101] and Le Roux and Rouanet [132] and Greenacre and Hastie [103].

Section 4.4 discusses the borrower's typologies, first describing the MCA results, and then the cluster analysis results. The last section concludes.

4.2 Mortgage products

The Australian mortgage market is dominated by variable-rate mortgages (VRMs), but products such as short-term fixed-rate mortgages (SFRMs), discounted variable-rate mortgages (HMs) and home equity loans (HEs) are also popular.

VRMs offer a flexible interest rate that varies with time, following the cost of funds of the bank and the interbank cash rate reported by the Reserve Bank of Australia (RBA). SFRMs offer certainty of repayment for a fixed period shielding borrowers from interest rate risk. In Australia, interest rates can be fixed between 1-5 years, or for 7 or 10 years. However, most SFRMs are fixed for less than 5 years. Early repayments are highly penalized for SFRMs. Indeed, the amount of early repayment cost will vary according to: (a) the amount of the unpaid loan balance, (b) the remaining term of the current fixed interest period, (c) the size of the early repayment, and (d) the difference between the market rates at the start of the fixed interest rate period and the date of the early repayment.

Discounted variable-rate mortgages, also known as 'honeymoons' (HMs), offer a discount off the variable rate for a fixed period of time. Loans that offer funds secured against the equity of a home are also available and are known as home equity loans (HEs). These funds are available for any personal use and are accessible in diverse ways.

In addition, some other home loans offered are the following: split loans, interest-only loans, low-documentation loans, and reverse mortgages. These latter loans have not been used in this study as they represent a very small proportion of residential owner-occupier home loans in the authorized deposit-taking institutions (ADIs) market.

In this paper, owner-occupier home loan products are classified into four main groups: standard variable-rate mortgages (VRMs), 'honeymoon' loans (HMs), short-term fixed-rate mortgages (SFRMs), and home equity loans (HEs).

Table 4.1 summarizes descriptive statistics for loan characteristics across these four mortgage categories.[9] The first column presents the loan characteristics and the remaining columns contain the mortgage products. The median loan size and property valuation for VRMs (AUD $202,747 and AUD $341,287 respectively) are larger than those for SFRMs (AUD $173,675 and AUD $310,262 respectively), and HMs (AUD $151,552 and AUD $262,561 respectively).[10] A median borrower contracting VRMs takes the largest loans in order to finance larger properties. Median repayments for HEs are zero because repayments are not scheduled and can be a once-off payment. HEs have the highest associated median interest rates, while HMs offer the lowest rates – as they offer 'teaser' rates. Although SFRMs offer higher LTVs than VRMs, borrowers contracting SFRMs take smaller loan sizes, which may suggest that these borrowers face more credit constrains or have higher income risk. The median payment-to-income ratio (PTIR) is largest for HEs; this is the case given that payments on HEs are not scheduled as explained previously.

Table 4.1: Summary Statistics for Loan Characteristics across Loan Types

Loan Characteristics	VRM	HM	SFRM	HE
Loan size	$202,747	$151,552	$173,675	$139,123
	(166,225)	(91,898)	(106,477)	(160,666)
Interest rate	7.07%	6.47%	7.19%	8.57%
	(0.75)	(0.92)	(0.77)	(0.69)
Monthly repayment	$1,371	$1,002	$1,219	$0
	(1,244)	(680)	(788)	(0)
Bank fees	$641	$621	$625	$747
	(161)	(118)	(196)	(168)
Bank fee-to-mortgage ratio	0.35%	0.40%	0.38%	0.50%
	(2.46)	(0.55)	(0.43)	(0.83)
Payment-to-income ratio (PTIR)	7.80%	5.40%	9.60%	21.50%
	(16.15)	(14.01)	(14.88)	(21.00)
Debt-servicing ratio (DSR)	44.84%	39.46%	45.79%	49.71%
	(18.70)	(15.02)	(15.81)	(19.58)
Loan-to-value ratio (LTV)	64.10%	64.89%	69.70%	59.16%
	(21.97)	(20.51)	(20.18)	(19.67)
Loan-to-income ratio (LTI)	2.51	2.66	2.47%	1.53%
	(1.73)	(1.57)	(1.38)	(1.53)
Property valuation	$341,287	$262,561	$310,262	$416,769
	(982,208)	(154,148)	(208,023)	(300,499)
Total observations	289,002	109,038	88,151	16,405

Medians and (standard deviation). Jan2003-Aug2008. Prices are in real terms Q1 2006.

[9] This table, and the next ones in this chapter, differ from the ones presented in the previous chapter in that they show medians (not means) for the period January 2003 to August 2008 (rather than January 2003 to May 2009).

[10] Although the median loan size of VRMs is larger than that of HEs, this is not the case for the median property valuation, because HEs have lower LTVs and borrowers can only take a limited loan from the equity in their property.

Table 4.2 presents descriptive statistics on borrower characteristics across loan types. The median borrower is 39 years old. While the median youngest borrowers take SFRMs, the oldest one take HEs. Borrowers taking HEs also have median older dependents and have lived at their current addresses for a longer time. Time at current address appears to be lower for borrowers taking SFRMs. This is counterintuitive as we expect more mobile borrowers – who have lived for shorter periods of time at their current address – to prefer VRMs. Median income is larger for borrowers taking HEs, followed by VRMs. As expected, borrowers selecting SFRMs and HMs are more income constrained than borrowers taking VRMs and HEs; borrowers taking HMs and SFRMs have the lowest median net wealth. Borrowers taking SFRMs have relatively higher credit scores, however, HEs have the largest scores.

TABLE 4.2: Summary Statistics for Borrower Characteristics across Loan Types

Variables	VRM	HM	SFRM	HE	Total
Applicant's age (years)	40	39	37	46	39
	(10.6)	(10.8)	(10.1)	(10.6)	(10.7)
Number of dependents	0	0	0	0	0
	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)
Age of youngest dependent (years)	5	5	5	7	5
	(5.1)	(4.9)	(4.8)	(5.1)	(5.0)
Time at current address (years)	4	4	3	6	4
	(6.9)	(6.6)	(6.1)	(7.7)	(6.7)
Time at current employment (years)	4	4	4	6	4
	(7.1)	(6.6)	(6.4)	(8.5)	(6.9)
Net monthly income	$5,299	$4,055	$4,780	$6,032	$4,920
	(3,302)	(2,246)	(2,897)	(4,435)	(3,142)
Gross monthly income	$6,730	$4,902	$6,013	$7,718	$6,158
	(5,266)	(3,628)	(4,565)	(7,000)	(4,996)
Household monthly income	$6,875	$4,962	$6,019	$7,730	$6,276
	(5,470)	(3,975)	(4,740)	(7,189)	(5,216)
Living expenditure	$1,265	$1,188	$1,234	$1,266	$1,243
	(665)	(671)	(591)	(772)	(659)
Short-term liabilities	$1,095	$867	$858	$2,535	$1,031
	(13,645)	(11,417)	(12,974)	(34,985)	(14,466)
Liquid assets	$22,398	$12,192	$16,939	$39,000	$18,900
	(97,451)	(66,440)	(81,748)	(126,161)	(90,969)
Net wealth	$331,439	$242,785	$258,158	$577,985	$301,163
	(408,281)	(307,765)	(333,053)	(556,748)	(390,935)
Credit score	492	481	493	715	496
	(181)	(197)	(179)	(143)	(185)
Total	289,002	109,038	88,151	16,405	502,596

Medians and standard deviation in brackets. Sample Jan2003-May2009. Prices in real terms Q1 2006.

Overall, the descriptive statistics suggest associations between borrower characteristics and mortgage types. To better examine these associations, Section 4.4 builds borrowers'

profiles according to their characteristics, and discusses the mortgage type matched to those profiles. The next section describes the methodology.

4.3 Method

This section explains the methodology used to build the Australian borrower typologies. We first discuss multiple correspondence analysis (MCA)[11] and then the cluster analysis used to obtain the six owner-occupier borrower types.

There is a variety of approaches used to distill measures of associations for large datasets with a number of categories; some familiar methods are principal component analysis (PCA) and cluster analysis. PCA is based on the eigenvalues of the data matrix. The usual approach is to choose the three orthogonal vectors, or principal components, that explain most of the variance, or alternatively those with eigenvalues greater than one. In this chapter, we follow an alternative approach, still using eigenvalues but for categorical data. This approach also has the advantage of facilitating an easily interpretable visual representation. This section explains the MCA technique, which uses a distance measure rather than the orthogonalization technique which underlies PCA. For details on the statistical coherence of these methods see Tenenhaus and Young [181].[12]

4.3.1 Multiple correspondence analysis (MCA)

Consider n individuals with p characteristics $X = \{X_1, \ldots, X_p\}$. Each characteristic X_j, $j = 1, \ldots, p$, has k_j categories. The total number of categories is $k = \sum_{j=1}^{p} k_j$. Define x_{k_j} such that:

$$x_{k_j} = \begin{cases} 1 & \text{if individual } i,\ i = 1, \ldots, n, \text{ is in category } k_j, \\ 0 & \text{otherwise} \end{cases}$$

[11] See Greenacre [102], Hayashi [108], Benzécri [23], Greenacre [101] and Le Roux and Rouanet [132] and Greenacre and Hastie [103].

[12] Tenenhaus and Young [181] shows the derivation for the eigen-analysis for the method of reciprocal averages, the analysis of variance, the principal component analysis, and the generalized canonical analysis and argues that they all lead to the same eigen equation as the one in the MCA analysis. The method of multiple correspondence analysis has also been named optimal scaling, optimal scoring, dual scaling, homogeneity analysis, scalogram analysis, quantification method.

and let $X_k = [X_{k_1}, \ldots, X_{k_p}] \in \mathbb{R}^{n \times k}$. Let $\phi_{k_j} = (\phi_{jl})_{l=1,\ldots,k_j}$ denote the scale value vector of category $l = 1, \ldots, k_j$ and $\tilde{X}_k = \sum_{j=1}^{p} X_{k_j} \phi_{k_j}$ be the scaled variable induced by the category scalings for X_k. Let $\phi_k = (\phi'_{k_1}, \ldots, \phi'_{k_p})'$ be the k dimensional vector of scale values and $\tilde{X} = [\tilde{X}_1, \ldots, \tilde{X}_p]$ the matrix of scaled variables.

The MCA solves:

$$\min_{\phi_k} Var\left[\frac{1}{p}\sum_{j=1}^{p}\sum_{l=1}^{k}\phi_{jl}x_{jl}\right] \quad s.t. \quad e'_k D\phi_k = 0,\ \phi'_k D\phi_k = np \tag{4.1}$$

$$\Leftrightarrow \quad \min_{a_{jl}} Var\left[\frac{1}{p}\sum_{j=1}^{p}\sum_{l=1}^{k}\sqrt{\frac{a_{jl}^2 n}{pn_{jl}}}x_{jl}\right] \quad s.t. \sum_{j=1}^{p}\sum_{l=1}^{k}\sqrt{n_{jl}}a_{jl} = 0,\ \sum_{j=1}^{p}\sum_{l=1}^{k}\sqrt{a_{jl}} = 1 \tag{4.2}$$

where D is a k dimensional diagonal matrix constructed with the non-null frequencies n_{jl}, e_k is a vector of k ones, and $a_k = \sqrt{\frac{n_{jl}}{np}}\phi_{jl}$. The solution ϕ^* of (4.1) and a^* of (4.2) are linked by the relationship:

$$\phi^* = (np)^{1/2} D^{-1/2} a^*. \tag{4.3}$$

The k components of ϕ^* are the category factors, $\hat{\psi}^* = (1/p)X\phi^*$ are the principal components, and the normalized variables $\psi^* = \hat{\psi}^*/(\lambda_h)^{1/2}$ are the subject factors. The eigenvalue λ_h is the variance explained by the hth principal component and $p\lambda_h/(k-p)$ is the proportion of the variance explained by the hth component. The contribution of category l, $l = 1, \ldots, k$, to the hth principal component, c_l^h, and the correlation between $\tilde{X_j}^h$ and ψ^*, are then given by

$$c_{jl}^h = \frac{n_{jl}(\phi_{jl}^*)^2}{np}, \quad Corr(\tilde{X_j}^h, \psi^*) = \left(\lambda_h p \sum_{l=1}^{k} c_{jl}^h\right)^2. \tag{4.4}$$

4.3.2 Cluster analysis: algorithm

Cluster analysis is a method that identifies homogeneous groups. It facilitates the construction of typologies of the statistical units. The clustering methodology in this section builds on the factors obtained from the MCA in the previous section. The results in the MCA application suggest three principal factors (dimensions): income and wealth, income versus wealth, and mobility.

We perform k-means clustering because our dataset is large. This method maximizes the between-cluster variance and minimizes the within-cluster variance relative to the mean of the cluster. The within-cluster variation forms homogeneous clusters. The algorithm initially assigns objects to a number of clusters, the observations are then successively reassigned to other clusters by minimizing the within-cluster variation. Observations are reassigned to new clusters only when the within-cluster variation is reduced out of that reallocation.

To be more precise, let $\mathbb{F} = (\mathbf{F}_1, \mathbf{F}_2, \mathbf{F}_3)$ be the space spanned by the 3 factors obtained from MCA. Each individual i ($i = 1, \ldots, n$) in the sample is associated with its coordinate $f_i = (f_{ji})_{1 \leq j \leq 3}$. Let $\mathbb{S} = \{S_k;\ k = 1, \ldots, 6\}$ be a partition of the n individuals into six sub-groups, $n_k = |S_k|$, and $\mu_k = (\bar{f}_{jk})_{1 \leq j \leq 3}$, $\bar{f}_{jk} = \frac{1}{n_k} \sum_{i \in S_k} f_{jk}^i$. The algorithm for each individual i, solves:

$$min_{S_k \in \mathbb{S}} \|f_i - \mu_k\|^2 \tag{4.5}$$

where $\|\cdot\|$ is the Euclidean norm. The algorithm has three steps:

1. Specify the initial clusters,[13] $\mathbb{S}^0 = \{S_k^0;\ k = 1, \ldots, 6\}$, and define the centroids $\mu_k^0 = (\bar{f}_{jk}^0)_{1 \leq j \leq 3}$;
2. For each observation i, compute $\|f_i - \mu_k\|^2$ and set $i \in S_{\bar{k}}^{(t)}$ if $\|f_i - \mu_{\bar{k}}\|^2 \leq \|f_i - \mu_k\|^2$ for all $k \neq \bar{k}$. Recalculate the centroids $\mu_k^{(t)} = (\bar{f}_{jk}^{(t)})_{1 \leq j \leq 3}$;
3. Iterate step 2 until $\|f_i - \mu_{\bar{k}}\|^2 < \epsilon$, for any $\epsilon > 0$.

4.4 Borrower characteristics and type of mortgage

Categorizing owner-occupier home loan borrowers helps lenders and regulators identify and assess risks more readily, particularly in a mortgage market where lenders hold the

[13] The number of clusters needs to be pre-assigned. The initial distribution of observations into the number of clusters indicates how the initial group centers are to be obtained. We assigned six clusters following the results from the MCA; see Figure 4.4. The starting condition of each observation into one of the six clusters was randomly assigned. We set up initial conditions in alternative ways (first observation, last observation, observation by predefined category), and obtained qualitatively the same results.

mortgage risk on balance sheets.[14] Mortgage providers can extract better profits by offering a limited variety of mortgage products tailored to segments of the population of potential borrowers. They can price discriminate as long as they can identify and differentiate groups of borrowers with different preferences. Meanwhile, this potentially allows a greater pool of borrowers to access housing credit that matches their preferences and constraints.

In this section, we build owner-occupier home loan borrower profiles for different mortgage contracts. First, we explore the association between individual borrower characteristics and types of mortgage contracts through multiple correspondence analysis (MCA). Second, we construct borrower typologies based on the mortgage product chosen using cluster analysis.

4.4.1 Association between borrower characteristics and mortgage types

We use multiple correspondence analysis (MCA) to find the association between borrower characteristics and the type of mortgage contracted. As discussed in Section 4.3.1, MCA transforms the association between categories of discrete variables into coordinates in a multidimensional space. Points in the same direction from the origin are highly associated. MCA assigns scale values to the categories of the discrete variables and maximizes the variance of those scores to find: (1) the associations between the variables, and (2) the proximity between individuals.

The variables used for the MCA in this paper are constructed from the previous literature on mortgage product choice – as discussed in the introduction. The empirical literature suggests that: mobility, income risk – age, low house valuation relative to income, income level, income volatility, and, to a lesser extent, lower expenditure on non-durable goods – and risk aversion – age, number of dependents, financial sophistication, lenient bankruptcy attitude, and presence of co-borrowers – are the factors that determine the choice of mortgage product. Factors reflecting wealth risk – such as net wealth, liquid assets, and short-term liabilities – are either omitted or irrelevant in the

[14] For example, Yates [191] argues that higher income earners and modest income households with no children were permitted repayment ratios of up to 40 or 50 percent of gross household income before 2007, while the 30 percent ratio remained for a single earner household with two children on average earnings.

existing literature. By contrast, in this chapter, we find that net wealth is an important factor in building borrower typologies.

The mean borrower is male, married, aged 40 years old, with income and wealth above the median. Most importantly, the mean borrower chooses a VRM in Australia.

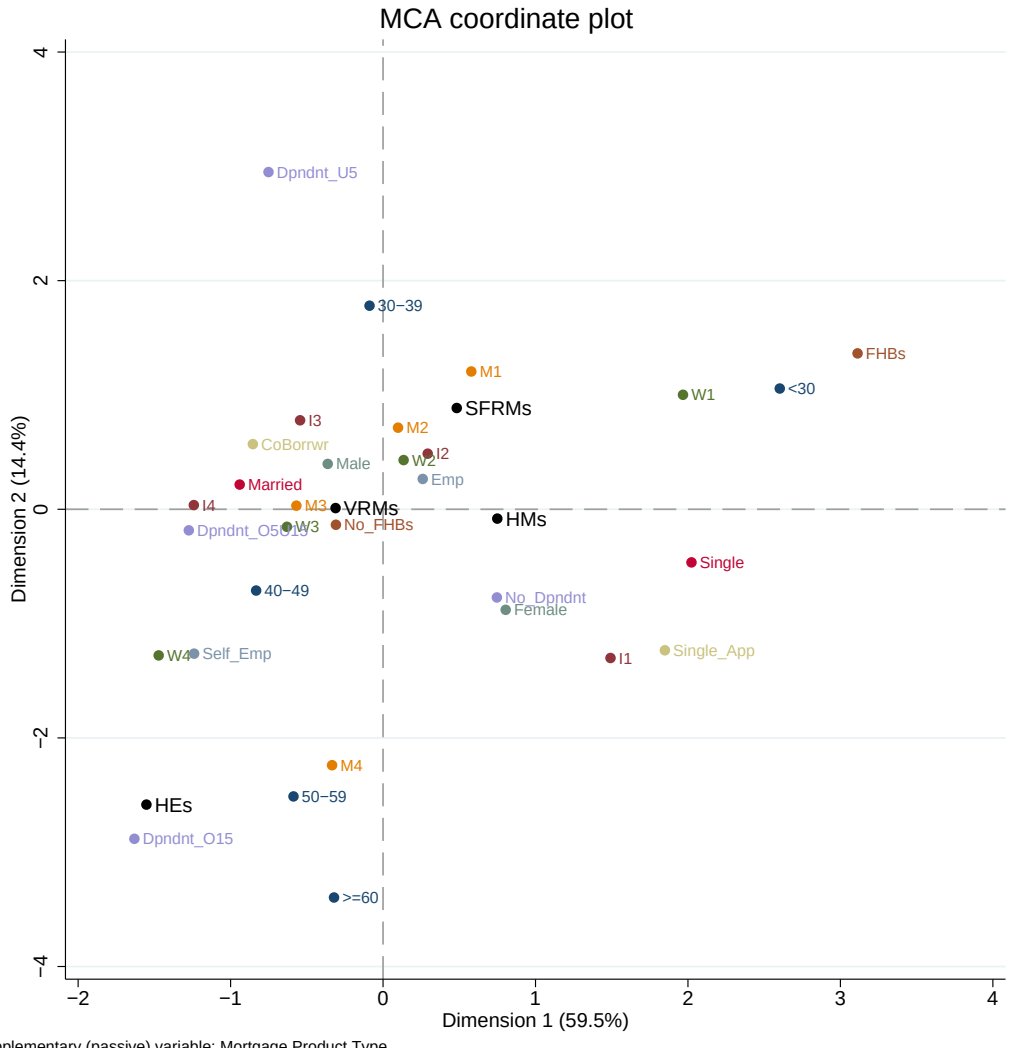
The MCA results find that single young applicants with low income and low wealth deviate from the mean borrower. Indeed, the first dimension is defined by single first-time home buyers (FHBs), aged under 30 years old, with income and wealth in the lowest quartiles, as shown in Figure 4.1. The young, income and wealth constrained borrower is associated with a SFRM or a HM. The settled middle age family with high levels of income and wealth is associated with HEs and VRMs. In this sense, the first dimension reflects income and wealth effects. This is supported by Figure 4.2 where dimension 1 is strongly determined by young applicants who have no dependents, have low income and low wealth.

Households with high income but low wealth are more likely to take VRMs and SFRMs, while households with high wealth but low income prefer mixed products such as HMs and HEs. In fact, the second dimension contrasts young families – married borrowers under 40 years old, who have low net wealth but high income, have dependents under 5 years old, and tend to be employees – with mature or senior households – borrowers over 40 years old, who are not mobile, have low income but high net wealth; see Figure 4.1. The association of young families to both SFRMs and VRMs is compelling. On the one hand, young families may prefer VRMs when financing larger houses with a high income and expectation of income growth. On the other hand, young families who are wealth constrained but have high income, may prefer SFRMs if they have high expenditure levels and are risk averse. In this sense, the second dimension is contrasting income and wealth, clearly illustrated by Figure 4.2.

Moreover, Figure 4.1 also suggests that HEs deviate, and are very distinctive, from SFRMs, VRMs and HMs. For example, HEs are associated with older borrowers and borrowers that have older dependents, while VRMs are more closely associated with the mean borrower. This is consistent with HEs being distinctive contracts in the sense that they are a line of credit associated to the equity of a property already owned by the borrower.

FIGURE 4.1 Multiple Correspondence Analysis.

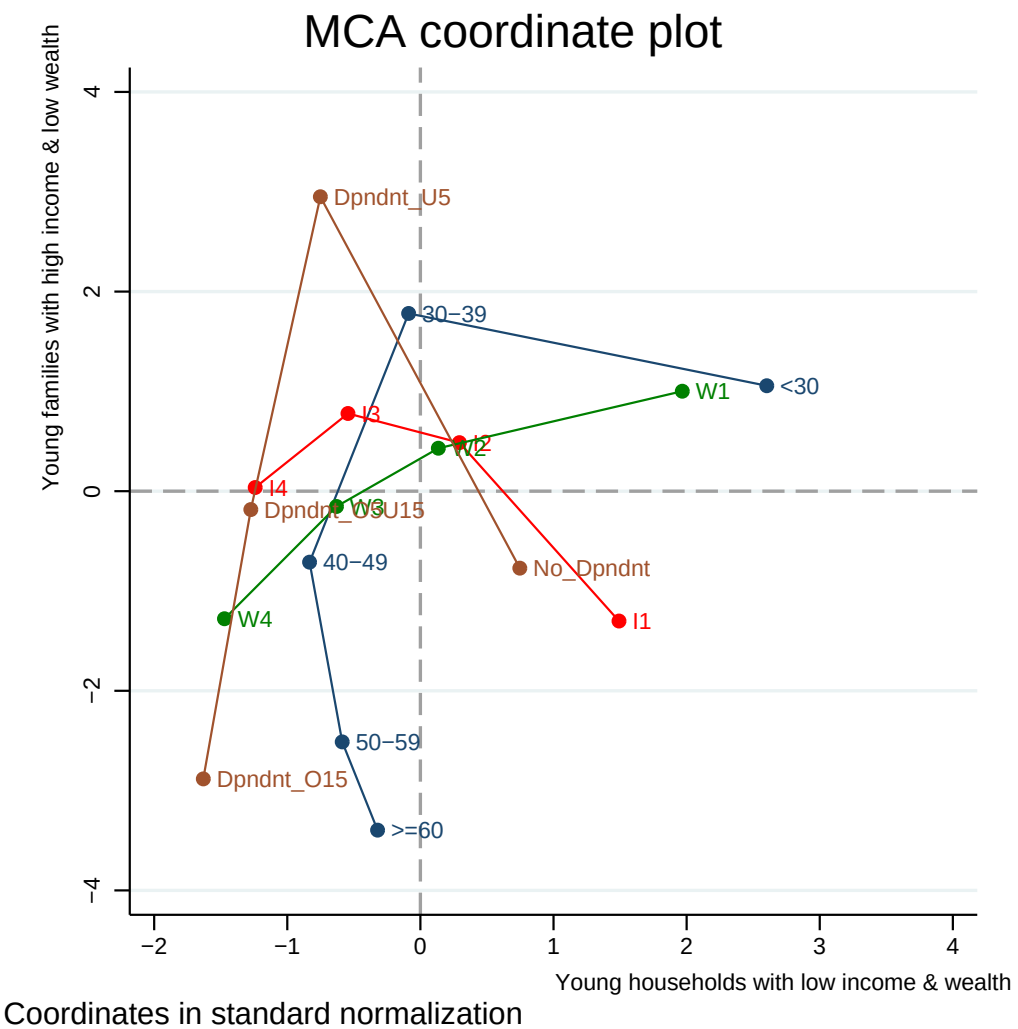
Each point represents the coordinates for a category in dimensions 1 and 2. Points away from the origin show categories that deviate from the mean. The four main mortgage types are depicted in black: $VRMs$ (variable-rate mortgages), $SFRMs$ (short-term fixed-rate mortgages), HMs ('honeymoon' mortgages) and HEs (home equity loans). The rest of the categories for borrower characteristic are depicted in colours. Age categories: < 30, $30 - 39$, $40 - 49$, $50 - 59$, $>= 60$. Income quartiles are $I1$, $I2$, $I3$ and $I4$, while surplus quartiles are $W1$, $W2$, $W3$ and $W4$. Marital status is indicated by $Single$ and $Married$. The categories for the mobility variable go from more mobile to less mobile: $M1$, $M2$, $M3$, $M4$, $M5$. $Female$ and $Male$ borrowers are also distinguished. Other categories are: No_Dpndnt (no dependents), $Dpndnt\_U5$ (dependents between 0 and 5 years old), $Dpndnt\_O5U15$ (dependents between 5 and 15 years old), and $Dpndnt\_O15$ (dependents over 15 years old); $FHBs$ (fist-time home buyers), non_FHBs (non-first-time home buyers or repeated buyers); $CoBorrwr$ (presence of a co-borrower), $Single\_App$ (single applicant); $Self\_Emp$ (self-employed borrowers), Emp (employees).



Supplementary (passive) variable: Mortgage Product Type
Coordinates in standard normalization

FIGURE 4.2 Multiple Correspondence Analysis: Dimensions 1 and 2.

Age categories: < 30, $30-39$, $40-49$, $50-59$, ≥ 60. Income quartiles are $I1$, $I2$, $I3$ and $I4$, while net wealth quartiles are $W1$, $W2$, $W3$ and $W4$. *No_Dpndnt* – no dependents, *Dpndnt_U5* – dependents between 0 and 5 years old, *Dpndnt_O5U15* – dependents between 5 and 15 years old, and *Dpndnt_O15* – dependents over 15 years old.
Dimension 1 contrasts low income and wealth levels with high income and wealth levels. The positive values of dimension 1 show borrowers under 30 yrs., with no dependents and income and wealth levels in the 1st and 2nd quartiles. The negative side of the horizontal axis shows borrowers over 30 yrs., with dependents and income and wealth levels in the 3rd and 4th quartiles. The positive side of dimension 1 reveals young households with low income and wealth, while the negative side shows families with high income and wealth.
Dimension 2 contrasts high income and low wealth levels with low income and high wealth levels. The positive values of dimension 2 show borrowers under 40 yrs., with dependents under 5 yrs., wealth on the 1st and 2nd quartile, but income on the 2nd, 3rd and 4th quartile. These borrowers represent young families with high income but low wealth levels. The negative values of the vertical axis reveals borrowers who are over 40 yrs., have dependents over 5 yrs. or no dependents, and have wealth on the 3rd and 4th quartiles but income on the 1st quartile.



Dimensions 1 and 2 in Figure 4.2 can be best interpreted by looking at each quadrant in the diagram. Quadrant I, for positive values of dimensions 1 and 2, shows low wealth borrowers; SFRMs are positioned in this quadrant. Quadrant II, for negative values of dimension 1 and positive values of dimension 2, shows high income borrowers. Quadrant III, for negative values of dimensions 1 and 2, shows high wealth borrowers, and HEs are positioned in this quadrant. Finally, quadrant IV, for positive values of dimension 1 and negative values of dimension 2, shows low income borrowers with HMs.

The MCA results suggest six groups of borrower characteristics. Figure 4.3 proposes four main groups of borrower characteristics when comparing the first two dimensions. When accounting for the third dimension, Figure 4.4 proposes six groups of characteristics. Section 4.4.2 exploits these groups of characteristics to build borrower typologies.

4.4.2 Typologies of borrowers

We use cluster analysis to build borrower typologies for the different mortgage contracts. We build six clusters following the MCA results in Figure 4.4. Figure 4.5 shows the results. The horizontal axis is the first dimension (income and wealth) obtained in MCA. The vertical axis refers to the second dimension (income versus wealth).[15]

The borrower typologies built are very informative. Tables 4.3 - 4.5 categorize the profiles of borrowers according to the variables proxing for risks – mobility risk, income risk, wealth risk and risk aversion. The first column in the tables indicates borrower characteristics, while the other columns describe the clusters. Table 4.3 shows clusters according to variables that are used to indicate risk aversion. Table 4.4 describes variables that proxy for income and wealth risks. Table 4.5 presents age and mobility indicators.

Cluster 1 is defined mostly by female borrowers (64 percent), between 30 and 60 years old, mainly single (only 33 percent are married or in a de-facto relationship), who have no dependents (81 percent), who have lived at their current address on average for 7.6 years, are mainly employees with income in the lowest quartile, and have medium wealth. We called this cluster the 'constrained (female) household'. Cluster 2 is mainly characterized by borrowers between 30 and 40 years old, who have lived on average at their current

[15]The third dimension is not provided, because it is less informative.

FIGURE 4.3 Multiple Correspondence Analysis: Sub-sets in Dimensions 1 and 2.

The four main mortgage types are depicted in black: $VRMs$ (variable-rate mortgages), $SFRMs$ (short-term fixed-rate mortgages), HMs ('honeymoon' mortgages) and HEs (home equity loans). The rest of the categories for borrower characteristic are depicted in colours. Age categories: < 30, $30-39$, $40-49$, $50-59$, $>= 60$. Income quartiles are $I1$, $I2$, $I3$ and $I4$, while surplus quartiles are $W1$, $W2$, $W3$ and $W4$. Marital status is indicated by $Single$ and $Married$. The categories for the mobility variable go from more mobile to less mobile: $M1$, $M2$, $M3$, $M4$, $M5$. $Female$ and $Male$ borrowers are also distinguished. Other categories are: No_Dpndnt (no dependents), $Dpndnt\_U5$ (dependents between 0 and 5 years old), $Dpndnt\_O5U15$ (dependents between 5 and 15 years old), and $Dpndnt\_O15$ (dependents over 15 years old); $FHBs$ (fist-time home buyers), non_FHBs (non-first-time home buyers or repeated buyers); $CoBorrwr$ (presence of a co-borrower), $Single\_App$ (single applicant); $Self\_Emp$ (self-employed borrowers), Emp (employees).
This figure reproduces Figure 4.1, however here we visually identify 4 distinctive groups of borrowers with different characteristics. Each group is contained in a box with borders in different patterns. The dashed box groups single borrowers under 30 yrs., who are first-time buyers and single applicants, and have income and wealth levels in the 1st quartile. A similar interpretation can be given to the other boxes.

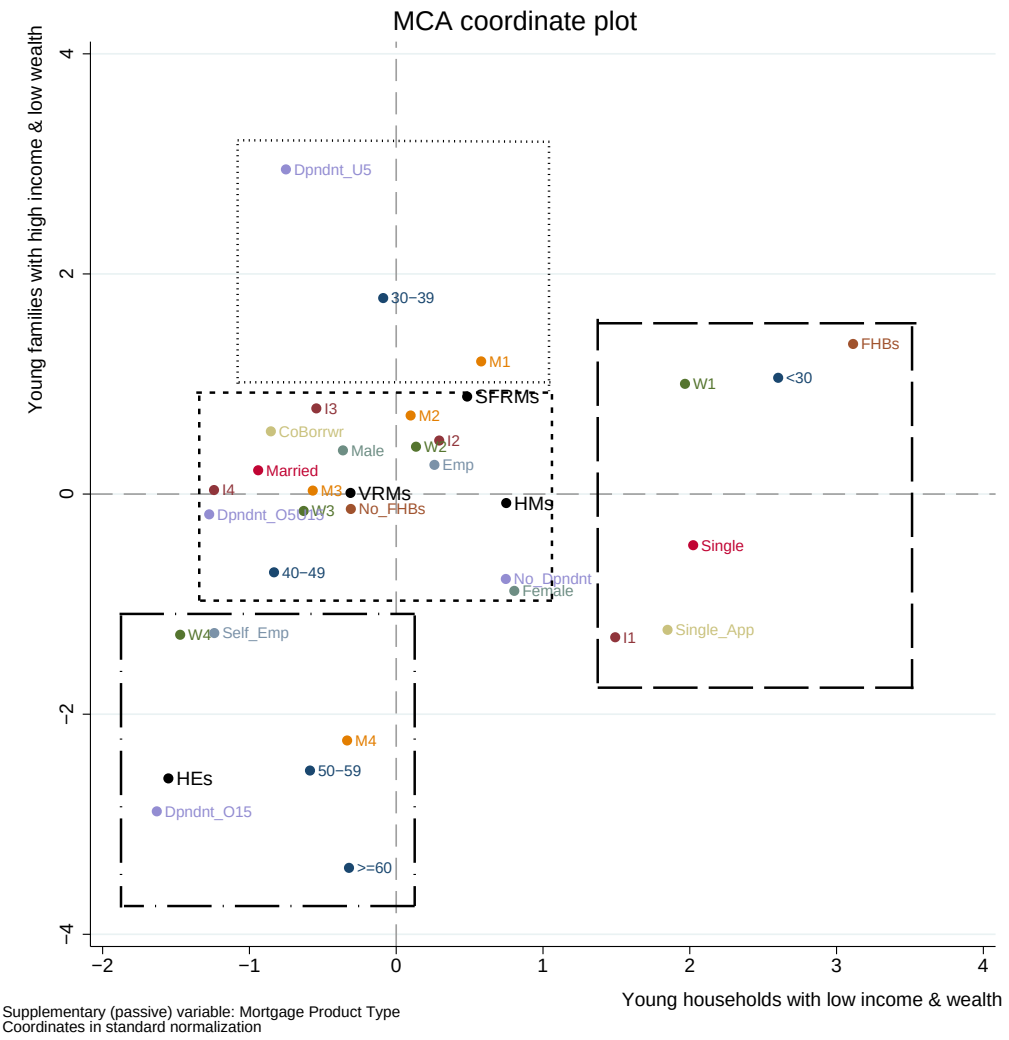
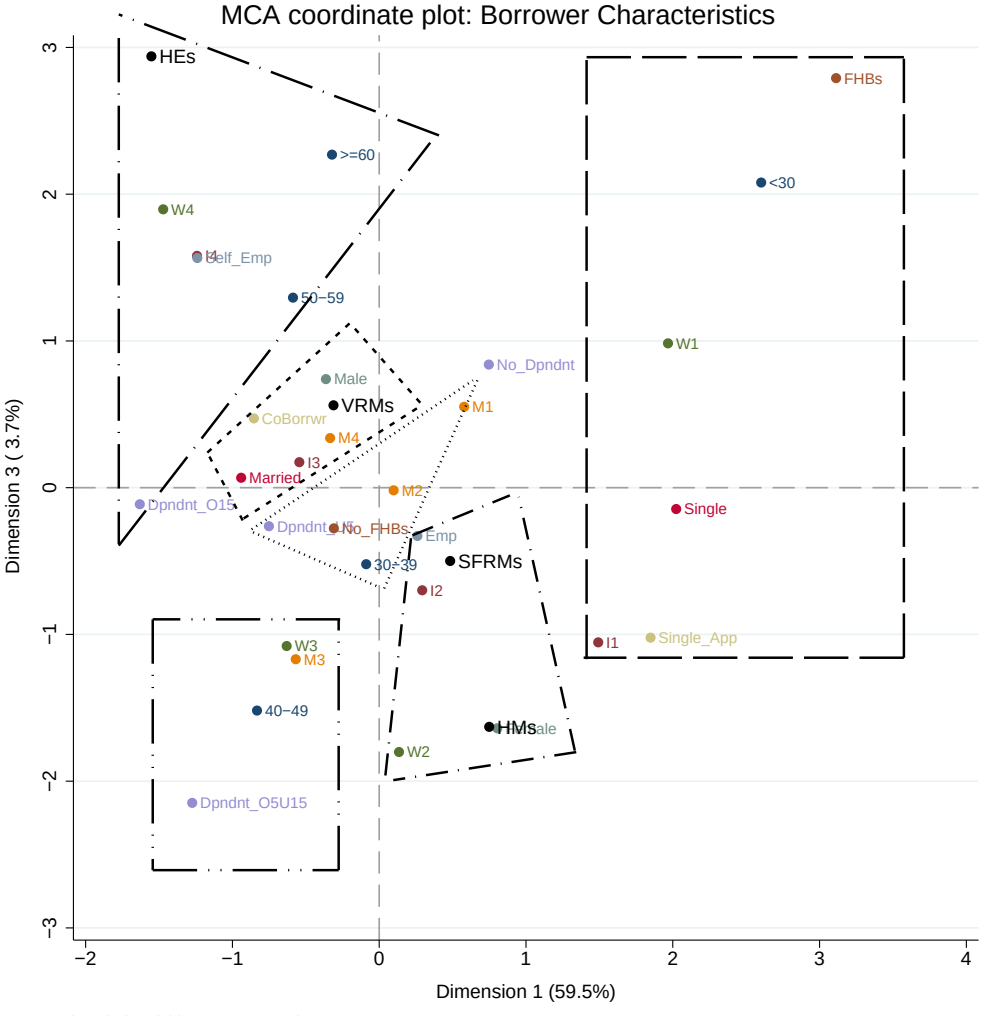


FIGURE 4.4 Multiple Correspondence Analysis: Sub-sets in Dimensions 1 and 3.

The four main mortgage types are depicted in black: $VRMs$ (variable-rate mortgages), $SFRMs$ (short-term fixed-rate mortgages), HMs ('honeymoon' mortgages) and HEs (home equity loans). The rest of the categories for borrower characteristic are depicted in colours. Age categories: < 30, $30-39$, $40-49$, $50-59$, $>= 60$. Income quartiles are $I1$, $I2$, $I3$ and $I4$, while surplus quartiles are $W1$, $W2$, $W3$ and $W4$. Marital status is indicated by $Single$ and $Married$. The categories for the mobility variable go from more mobile to less mobile: $M1$, $M2$, $M3$, $M4$, $M5$. $Female$ and $Male$ borrowers are also distinguished. Other categories are: No_Dpndnt (no dependents), $Dpndnt\_U5$ (dependents between 0 and 5 years old), $Dpndnt\_O5U15$ (dependents between 5 and 15 years old), and $Dpndnt\_O15$ (dependents over 15 years old); $FHBs$ (fist-time home buyers), non_FHBs (non-first-time home buyers or repeated buyers); $CoBorrwr$ (presence of a co-borrower), $Single\_App$ (single applicant); $Self\_Emp$ (self-employed borrowers), Emp (employees).
This figure presents the MCA coordinates in dimensions 1 and 3, and adds two more groups to the four groups in Figure 4.3. Each group is contained in a box with borders in different patterns, as before. The dashed box still represents single borrowers under 30 years old, who are first-time buyers, are single applicants and have income and wealth levels in the first quartile. We find the four groups already presented in dimensions 1 and 2 in Figure 3, but now we detect 2 more groups.



Supplementary (passive) variable: Mortgage ProductType
Coordinates in standard normalization

Table 4.3: Clusters Overview: Risk Aversion

Variables	**1**	**2**	**3**	**4**	**5**	**6**
Risk Aversion						
Female	64.3%	16.9%	22.3%	29.9%	38.3%	15.4%
Married	32.9%	87.7%	83.4%	21.1%	93.5%	87.2%
Co-borrower	13.6%	95.3%	76.8%	44.0%	85.9%	92.5%
FHB	2.1%	5.8%	1.2%	45.4%	0.4%	1.9%
Number of Dependents	0.3	1.4	0.3	0.1	1.6	0.8
	(0.7)	(1.1)	(0.7)	(0.4)	(1.1)	(1.1)
Age Youngest Dependent	9.9	2.8	13.3	2.8	8.6	6.9
	(4.6)	(2.5)	(5.2)	(2.9)	(4.2)	(4.8)
No Dependents	80.9%	25.0%	83.4%	94.1%	19.8%	61.2%
Dependents < 5 yrs	2.5%	64.2%	0.6%	5.1%	12.5%	15.3%
Dependents $5 - 15$ yrs	14.4%	10.8%	9.1%	0.8%	64.0%	21.7%
Dependents > 15 yrs	2.3%	0.04%	7.0%	0.05%	3.6%	1.8%
Total	88,514	101,631	60,449	76,341	84,445	91,216

Sample proportions %, means and (standard deviations).

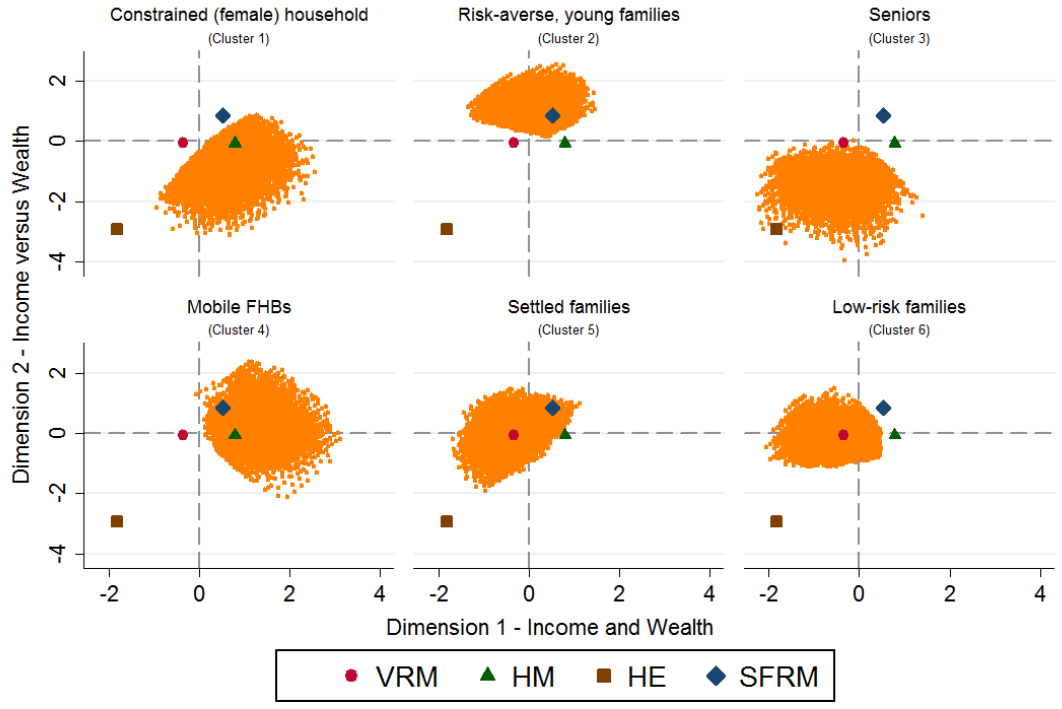
Table 4.4: Clusters Overview: Age and Mobility

Variables	**1**	**2**	**3**	**4**	**5**	**6**
Age	44.3 yrs	34.3 yrs	54.1 yrs	29.0 yrs	42.0 yrs	42.8 yrs
	(10.6)	(4.7)	(8.7)	(6.7)	(5.6)	(8.9)
Age < 30	7.0%	12.7%	1.1%	67.6%	0.5%	4.7%
Age $30 - 39$	25.8%	77.2%	2.9%	26.8%	29.3%	34.3%
Age $40 - 49$	37.3%	9.9%	19.2%	3.3%	64.2%	38.5%
Age $50 - 59$	22.7%	0.3%	52.7%	1.9%	5.7%	19.2%
Age > 60	7.4%	0.01%	24.1%	0.5%	0.3%	3.3%
Mobility						
Time at current address	7.7 yrs	2.8 yrs	11.8 yrs	4.3 yrs	7.0 yrs	5.2 yrs
	(7.6)	(2.7)	(9.1)	(6.6)	(5.4)	(5.3)
$<$ 2yrs.	16.9%	36.3%	8.3%	43.0%	11.9%	23.3%
$2 - 4$ yrs.	19.1%	32.4%	10.7%	29.3%	15.5%	25.3%
$4 - 6$ yrs.	17.2%	18.8%	10.6%	9.8%	20.0%	19.6%
$6 - 8$ yrs.	10.1%	8.0%	6.0%	2.6%	17.3%	10.0%
> 8 yrs.	36.7%	4.5%	64.4%	15.3%	35.4%	21.8%

Sample proportions %, means and (standard deviations).

FIGURE 4.5 Cluster Analysis.

The horizontal axis depicts dimension 1 and the vertical axis depicts dimension 2, as already defined in the previous figures (for MCA). Each graph represents a cluster formed with the individual observations. The four main mortgage types are identified: VRM (variable-rate mortgages), FRM (short-term fixed-rate mortgages), HM ('honeymoon' mortgages) and HE (home equity loans). The clustering has been performed by using the k-means algorithm, with random initial observations, and an Euclidean distance definition.



address for only 3 years, have medium income and medium wealth, are mainly employees; most of them are married, have a co-borrower, and have dependents under 5 years old. We named the second cluster 'risk averse young families'. Cluster number 3 has older borrowers (most borrowers are over 50 years old), most of them are married and have a co-borrower, have lived at their current address on average for 12 years, have high income and large wealth (most likely through the equity in their houses), and have no dependents.[16] This cluster was named the 'seniors' cluster. Cluster 4 has primarily borrowers under 30 years old, who have lived at their current address on average for 4 years, have medium income and the lowest wealth levels, are mostly employees, have no dependents, only 20 percent of them are married and, most interestingly, 45 percent

[16]Dependents refer to children or adults living under the same roof and who receive income support from the main borrower. 'No dependents' does not necessarily mean that these borrowers have no children.

TABLE 4.5: Clusters Overview: Income and Wealth Risks

Variables	**1**	**2**	**3**	**4**	**5**	**6**
Income Risk						
Gross Monthly Income	$4,202 (2,147)	$7,335 (3,711)	$9,403 (7,366)	$6,076 (3,522)	$6,252 (2,960)	$10,145 (6,382)
1st Income quartile	62.3%	10.3%	18.5%	32.4%	22.2%	5.7%
2nd Income quartile	24.1%	31.3%	14.9%	29.3%	36.4%	12.8%
3rd Income quartile	7.5%	36.5%	21.1%	23.9%	29.9%	28.1%
4th Income quartile	2.1%	22.0%	45.5%	14.5%	11.5%	53.4%
Self-Employed	9.84%	7.40%	48.74%	5.64%	12.93%	27.50%
Wealth Risk						
Wealth Stock	$287,377 (203,929)	$282,028 (202,832)	$900,930 (565,512)	$144,920 (162,346)	$343,811 (200,222)	$623,562 (428,681)
1st Wealth quartile	26.1%	29.9%	2.7%	78.0%	8.7%	8.0%
2nd Wealth quartile	38.2%	35.6%	4.4%	12.5%	41.0%	11.2%
3rd Wealth quartile	27.8%	26.6%	14.4%	6.4%	41.3%	26.7%
4th Wealth quartile	8.0%	8.0%	78.6%	3.1%	9.1%	54.1%
Total	88,514	101,631	60,449	76,341	84,445	91,216

Sample proportions %, means and (standard deviations).

of them are first-time home buyers (FHBs). Cluster 4 has been named 'Mobile FHBs'. Cluster 5 is formed mainly by married borrowers between 40 and 50 years old, who have a co-borrower, have lived in their current address on average for 7 years, with medium income and medium wealth (13 percent of them are self-employed), and have dependents between 5 and 15 years old. This cluster represents 'settled families'. Finally, cluster 6 describes married borrowers in their 30s and 40s, that lived in their current address on average for 5 years, have no dependents or have dependents over 15 years old, and in particular have very high income and wealth (27.5 percent of them are self-employed). We called this cluster the 'low-risk families'.

We then observe the mortgage products that these borrower profiles are choosing. Figure 4.5 suggests that: (1) young constrained households with a large proportion of female main applicants tend to prefer the initial discounts on the variable-rate offered in HMs;

(2) risk averse young families prefer the short-term certainty of SFRMs; (3) senior borrowers are more prone to contract HEs and VRMs; (4) Mobile first-time home buyers prefer SFRMs and HMs, suggesting they prefer certainty and are financially constrained; (5) settled families are likely to choose HMs, SFRMs or VRMs; (6) low risk families take more VRMs. Table 4.6 summarizes these results.

TABLE 4.6: Borrower Typologies

Cluster	Profile	Borrower Characteristics	Mortgage type
1	Constrained (female) household	Females, Low income, medium wealth, 40-50 yrs., no dependents, not mobile.	HMs
2	Risk averse, young families	Married, co-borrowers, 30-40 yrs., dependents under 5 yrs., medium income, medium wealth, mobile.	SFRMs
3	Seniors	Self-employed, 50-60 yrs., high income, high wealth, married, co-borrower, no dependents, not mobile.	HEs, VRMs
4	Mobile FHBs	Under 30 yrs., FHBs, low wealth, medium income, mobile, no dependents.	SFRMs, HMs
5	Settled families	40 yrs., medium income, medium wealth, married, co-borrower, dependents 5-15 yrs., mobile.	HMs, SFRMs, VRMs
6	Low risk families	30-50 yrs., high income, high wealth, self-employed, married, co-borrower.	VRMs

Although VRMs are the predominant mortgage product taken by Australian borrowers, a larger proportion of VRMs are held by borrowers with high income and wealth levels – borrowers described in clusters (3) and (6). This is an important consideration when assessing the initial impact of monetary policy transmission as borrowers who are first affected by the increase in market rates are those who can face this shock more comfortably. A relatively large proportion of these borrowers are self-employed; they may find the features of a flexible VRM more suitable for their volatile income and tend to be more financially savvy.

The profile of borrowers taking HEs – cluster (3) – matches the purpose of this mortgage

product. HEs are designed to allow homeowners to smooth consumption through the equity of their property, particularly in periods of strong house price growth. In our results, HEs loans are mainly taken by borrowers over 50 years old, with high income and high wealth, who have lived at their current residence for almost 12 years on average. HEs are increasingly popular loans in Australia, but are still relatively expensive products. Cluster (3) chooses between HEs and VRMs.

Borrowers selecting HMs and SFRMs remain heterogeneous within mortgage product. SFRM are preferred contracts for young risk averse families, settled families, and mobile first-time home buyers (FHBs) – typologies (2), (5) and (4) respectively. HMs attract young (female) households, settled families and mobile first-time home buyers (FHBs) – typologies (1), (5) and (4). In general, we observe that borrowers selecting HMs and SFRMs are more financially constrained (low income and wealth), more risk-averse (females, and borrowers with dependents under 5 years old) and less financially experienced (young, FHBs, not self-employed) than borrowers taking HEs and VRMs.

Settled families, with average income and wealth levels, appear to have more mortgage product options to select from – VRMs, SFRMs and HMs. These results are coherent with the findings in Devlin [72] who argue that high income households are more price sensitive and choose a mortgage based on product features.

Income and wealth constrained borrowers – typologies (1), (2) and (4) – have fewer choices, consistent with Devlin [72] results. These borrowers may be mainly choosing based on personal recommendation or on the basis of professional advice. Constrained (female) households are mainly taking HMs. These borrowers are the most income constrained in the sample, which suggest they are seeking the lower early prepayments in HMs. HMs are designed to attract newer constrained borrowers. Risk averse young families, as predicted by the mortgage choice literature, prefer SFRMs. However, we observe in this cluster, a group of borrowers (with revealed characteristics to the left of the vertical line in Figure 4.5) that appear to be under-served; they do not access mortgage products associated to their characteristics, and may be well suited for a new type of mortgage product. These sub-set of borrowers are slightly older, with higher income but lower wealth. Mobile FHBs take HMs and SFRMs, which offer them lower initial payments and short-term certainty in repayments. Product differentiation and, in particular, the option of HMs may be allowing these borrowers to access housing credit

earlier than they would. However, this cluster exhibits a sub-set with characteristics spread away to the mortgages offered; see cluster (4) in Figure 4.5. This suggests that there may be potential for designing new mortgage products to better serve these FHBs. We propose young FHBs, with low wealth and medium income, who are mobile and have no dependents, may prefer flexible mortgages with low initial costs and low early prepayment costs, such as a capped-VRM covered mortgage bonds.[17]

In contrast to the predictions in the mortgage choice literature, the two typologies which have spent less time at their current address – which is expected to proxy for mobility – do not select VRMs, but rather SFRMs and HMs. A few of reasons could drive these results. On the one hand, the mobility motive on VRMs may not be strong in the Australian mortgage market because SFRMs offer fixed rates only for a short term (3-5 years). On the other hand, the time at current address may not be a good proxy for mobility. Although it has been previously used in the literature, time at current address is correlated with the borrower's age.[18] These effects will be untangled in the following chapters where we also propose other proxies for mobility.

The results reveal that higher income, wealthier, lower risk borrowers are clustered between more product choices, suggesting they have more options to choose from. However we observe that lower income, low wealth customers have fewer choices, and typically are served by just one mortgage product. These outcomes are consistent with the literature on mortgage provider choice. These results may just reflect the bank's business and marketing strategy, and is only conclusive for part of the Australian mortgage market – albeit 16 percent of the mortgage market share,[19] and representative of the Australian mortgage market as suggested in the previous data description chapter. The results also show that more risk averse borrowers select SFRMs, but we don't find evidence of a strong mobility motive to take VRMs.

[17] See Svenstrup, M. [2002], 'Mortgage choice - The Danish case', *Working Paper*, Institut for Finansiering, Handelshøjskolen i Århus, http://www.svenstrup.net/pdfdocs/dkkmtg.pdf; and see Frankel, A., Gyntelberg, J., Kjeldsen, K., and Persson, M. [2004], 'The Danish mortgage market', *BIS Quarterly Review*, Bank for International Settlements, March, 95–110, http://www.bis.org/publ/qtrpdf/r_qt0403h.pdf.

[18] The correlation coefficient between borrower's age and years spent at their current address is 0.29.

[19] See APRA, Monthly Banking Statistics, http://www.apra.gov.au/adi/publications/pages/monthly-banking-statistics.aspx.

Our results are robust to different period sub-samples[20], and to different MCA methodologies.[21] Our results are also consistent through different clustering methodologies.[22]

4.5 Conclusion

This paper builds typologies of borrowers that are choosing between the main four types of mortgage contracts offered in Australia between January 2003 and August 2008 for a representative major bank. We built these typologies using MCA and cluster analysis.

Our analysis shows that 'constrained (female) households' – households, where a large proportion of applicants are women in their forties, with low income and medium wealth, not mobile and with no dependents – prefer discounted variable-rate mortgages such as 'honeymoon' home loans (HMs). 'Risk averse young families' with married borrowers in their thirties, who have children under five years old, who have spent few years at their current address, and have medium income and medium wealth, are more prone to choose short-term fixed-rate mortgages (SFRMs). 'Senior' households, with a considerable proportion of self-employed married borrowers aged fifty years old or over, who have no dependents, are not mobile, have co-borrowers and have high income and high wealth, tend to choose home equity loans (HEs) and variable-rate mortgages (VRMs). 'Mobile FHBs' are mobile borrowers under thirty years old with low wealth and medium income, with no dependents, who decide to purchase their first home; these borrowers prefer the certainty of repayments or the early discount on repayments, and tend to choose SFRMs or HMs. 'Settled families' – married borrowers aged in their forties, relatively mobile, with children between five and fifteen years old, with medium income and medium wealth and a co-borrower – are more likely to choose VRMs, SFRMs or HMs. 'Low risk families' – married borrowers between thirty and fifty years old, with a co-borrower, high income and high wealth, and a large proportion of self-employed status – are mainly willing to take variable-rate mortgages (VRMs).

[20] Similar results were obtained for a sample between January 2003 and May 2009, but we decided to exclude the global financial crisis period to have a more consistent analysis. We also carried out our analysis for the sub-sample January 2003 and January 2008 and similar clusters were obtained.

[21] We performed MCA with the adjusted Burt matrix, and we also carried out the analysis with the Indicator matrix, the Burt matrix and by applying joint correspondence analysis (JCA). We tried alternative combinations of active and supplementary variables. In every step we get consistent results.

[22] We defined different clustering processes such as k-means and k-medians algorithms, we experimented with different assigned number of clusters, we defined different distance measures, and we checked the robustness of the starting conditions. The only distance measure definition that appears to provide different results is the absolute distance.

Our results show that borrowers that are associated with VRMs are generally less risk averse, financially experienced and, most importantly, have high income and wealth levels. These results suggest that although most Australian borrowers bear the interest rate risk in a VRM, they were in a strong financial position to face an interest rate shock between January 2003 and August 2008. This evidence in hindsight becomes consistent with the effects of the global financial crisis in Australia (discussed in previous chapters).

In addition, we easily differentiate borrowers who choose HEs; these are older, relatively less mobile, have high income but, more importantly, high wealth levels, are married and have no dependents. We suggest these products are well matched to borrowers in the mid-point of their life-cycle, however in the Australian context they have been relatively expensive products requiring borrowers to have a sound financial position.

We observe that borrowers choosing SFRMs are more risk averse and are income and/or wealth constrained, while borrowers choosing HMs are mainly only income constrained. However we find that borrowers selecting HMs and SFRMs remain heterogeneous within mortgage product. SFRM are preferred contracts for young risk averse families, settled families, and mobile first-time home buyers (FHBs). HMs attract young (female) households, settled families and mobile first-time home buyers (FHBs).

Settled families, with average income and wealth levels appear to have more mortgage product options to select from, however, more income and wealth constrained borrowers have fewer choices. Constrained (female) households are mainly taking HMs, suggesting they are seeking the lower early prepayments in HMs. Risk averse young families, as predicted by the mortgage choice literature, prefer SFRMs. Mobile FHBs take HMs and SFRMs, which offer them lower initial payments and short-term certainty in repayments.

In contrast to the predictions in the mortgage choice literature, borrowers who have spent less time at their current address – who are expected to be more mobile – do not select VRMs, but rather SFRMs and HMs. We explore this issue in the following chapters.

Moreover, we argue that product differentiation and, in particular, the option of HMs, may be allowing borrowers to access housing credit earlier than they otherwise would. However, we observe some potentially under-served group of borrowers.

The exercise in this chapter has allowed us to identify groups of borrowers with common characteristics selecting a particular mortgage product. This has enabled us to explore mortgage product differentiation. The analysis reveals that higher income, wealthier, lower risk borrowers are clustered between more product choices, whereas the lower income, low wealth customers have fewer choices close to their revealed borrower characteristics. These outcomes are consistent with the literature on mortgage provider choice.

The results presented in this chapter (and the previous one) suggest that HMs and SFRMs share many features – such as fixity on interest rates or on discount period, and relatively high early prepayment costs; for this reason we decided to group HMs and SFRMs as alternatives to the predominant VRM contract. The following chapters present a parametric study on choice between VRMs and the alternative (HMs and SFRMs), and it focuses on the role of borrower characteristics on the mortgage choice determination. We also exclude home equity loans (HEs) in the following analysis, as these contracts are very distinctive and deserve separate analysis left for future work.

Chapter 5

Mortgage Choice Determinants: The Role of Risk and Bank Regulation

5.1 Introduction

The structure of mortgage markets varies substantially around the globe; Warnock and Warnock [185], Scanlon et al. [166], Badarinza et al. [18], Paiella and Pozzolo [150]. The benchmark U.S. market is dominated by securitized long-term (30-year) fixed-rate mortgages (FRMs), while the prevalence of variable-rate and short-term fixed-rate products is generally higher in other countries; Lea [133] and Lea [134].[1] Currently, considerable attention is focused on the diversity of mortgage product choices, in part due to the importance of the U.S. mortgage market in precipitating the global financial crisis, but also reflecting the key role that mortgages play in monetary policy transmission; Calza et al. [41] and Landier et al. [131]. Mortgage product choice is additionally relevant in assessing market completeness and risk management, and hence has strong implications for optimal householder outcomes; Campbell and Cocco [43], Miles [144].

This paper considers mortgage product choice in Australia where mortgage transactions are not influenced by institutional structures such as Fannie Mae and Freddie Mac

[1] For example, Badarinza et al. [18] report the share of adjustable-rate mortgages (ARMs) in the U.S. is the lowest at 23 percent, while two thirds of countries in their study have an ARM share of over 50 percent.

in the U.S., government mortgage insurance (in the U.S., Netherlands and Canada) or government security guarantees (in U.S., Canada and Japan); see Campbell [42], Lea [134], Green and Wachter [100], and Frame and White [90]. Outside the U.S., the structure of the mortgage market can be quite different. In Australia, securitization plays a minimal role in sourcing funds for major banks, there is strong prudential regulation, but no public mortgage insurance scheme and no government deposit guarantee existed prior to the impact of the global financial crisis in 2008-09. Importantly, the Australian mortgage market is dominated by variable-rate mortgages (VRMs) – a credit foncier loan written for terms of up to 30 years, with the interest rate adjustable at the discretion of the bank.[2] These loans are predominantly bank-originated, and form an important component of bank-balance-sheets. (As much as 60 percent of Australian bank loans are for residential housing, Davis [61].) The resilience of the Australian financial system during the global financial crisis has prompted interest in a more careful examination of its institutional structures.

The comparison of mortgage products across countries is complex in that variable-rate mortgage products are not homogeneous across countries. For example, in the U.S. adjustable-rate mortgages (ARMs) have periodic rate adjustments (hybrid ARMs 3/1, 5/1); in Spain, Ireland and the UK, 'tracker' loans adjust the interest rate in line with a market benchmark rate;[3] Canada caps the maximum variable rate; while in Australia loan rates are reset at the discretion of the lender. This distinction has not been emphasized in the literature.

Australian households choose between a VRM and a range of other mortgage products. This does not include FRMs such as commonly described in the international literature with a rate fixed for a very long term. Instead, applicants may choose between 'honeymoon' mortgages (HM), with a discount on the variable interest rate for a fixed period of time, and a loan with a short-term (3-5 years) fixed interest rate (SFRM).[4] Borrowers cannot prepay or exit these contracts without penalties (unlike FRMs in the U.S.). Growing interest in a greater range of mortgage products is emerging in the literature, with consideration of alternative mortgage products (AMPs) – contracts with zero or negative amortization; see Brueckner et al. [36], Cocco [50], LaCour-Little and

[2]See Stewart et al. [176]. Owner-occupied interest rate expenses are not tax deductible, and mobility costs are increased by transaction taxes imposed by state governments.

[3]Goggin et al. [99] suggest that since the global financial crisis, banks in Ireland have reduced their offerings of 'tracker' loans in preference for variable-rate loans set at the lender's discretion.

[4]These Australian SFRMs are somewhat similar to the hybrid ARMs in the U.S. market.

Yang [128], Scanlon et al. [166] – or complex mortgages (CMs) – products categorized by low introductory 'teaser' interest rates, short interest rate reset periods and deferred principal repayment; see Amromin et al. [10]. For the purpose of this study, we classify HMs and SFRMs in Australia as CMs that offer an alternative to the commonly taken VRMs.

The paper has two main contributions. We confirm the joint theoretical results of Campbell and Cocco [43]. Risk averse households which require a large mortgage, have low equity, are exposed to income risk or any combination of these, choose mortgage products which manage the impact of the interest rate risk through loans with greater certainty in repayment scheduling. We find that borrowers with high loan-to-value ratios (LTVs) are more likely to prefer certainty in their mortgage repayments when they have low, unstable income and are risk averse. Households subject to mobility risk trade-off between payment certainty and the costs of early mortgage termination to obtain flexibility. This paper provides the first empirical evidence of the joint significance of these theoretical results; whilst evidence for some risk category has been found in separate studies, there is no existing evidence identifying all categories. Secondly, bank mortgage originators are subject to Basel capital rules, which give concessions to mortgage loans with lower LTV. Consequently, banks may be expected to adjust their mortgage offerings to attract households with higher equity. Using the capital requirement rules applicable in Australia, we show that high LTV mortgage applicants are more likely to choose away from VRMs when facing income risk and constraints, however, low LTV borrowers choose away from VRMs when facing risk-aversion. These results disentangle the theoretical preferences outlined in Campbell and Cocco [43] and Piskorski and Tchistyi [153].

Borrower characteristics are expected to play a role in mortgage product choice because they are indicators of borrowers' exposure to, and attitudes towards, various kinds of risks. Theoretically, borrower characteristics relate directly to income risk, wealth risk, mobility risk and borrowing constraints as in Campbell and Cocco [43]. Theory predicts that consumers facing *income risks* will prefer to take a product which reduces the variability of their repayments. Tests of this proposition have been attempted in the literature using a variety of proxies with little success in obtaining significant relationships.[5] The potential for future income growth, reducing the importance of mortgage

[5]Proxies for income risk used have been the presence of children, non-durable expenditure, age, income levels and growth, education, occupation, self-employment or public employee, and income volatility

payments in the household budget may induce households towards products where they bear more interest rate risk, but again the evidence is mixed.[6] *Wealth risk* enters both via borrowing constraints and the potential for capital gain/loss; Gabriel and Rosenthal [93] show how expected housing price growth encourages home ownership and Yamashita [189] shows that low wealth-to-income homeowners are more sensitive to house price appreciation. When faced with expected housing price gains households may be willing to bear more interest rate risk. Borrowing constraints are expected to influence households away from ARM products – particularly for first-time home buyers. However, 'honeymoon' products (HMs) are designed to reduce early period payments and may attract these households. Households facing *mobility risk* should choose products with the least penalty for change, as confirmed in the U.S. literature; Dhillon et al. [73], Brueckner and Follain [34], Sa-Aadu and Sirmans [162], Coulibaly and Li [54], Fortowsky et al. [88].

In addition to these risk factors, the existing literature also suggests that female borrowers may have more risk averse preferences; Barber and Odean [21], Borghans et al. [28], Agnew et al. [4], Bernasek and Shwiff [25], and Watson and McNaughton [186].[7] Similarly, risk aversion has been shown to increase with age; see see Morin and Suarez [146], Bellante and Saba [22] and Riley Jr and Chow [157].[8]

Overall, the literature contains mixed evidence on the role of borrower characteristics in mortgage choice. The majority of the evidence concerns U.S. households choosing between FRMs and ARMs where Dhillon et al. [73], Brueckner and Follain [34], Phillips and VanderHoff [152], and Vickery [183] find borrower characteristics to be weak determinants of mortgage product choice, although they play a role in Sa-Aadu and Sirmans [162], Coulibaly and Li [54], Fortowsky et al. [88] and Amromin et al. [10]. International evidence is limited: Paiella and Pozzolo [150] find little role for borrower characteristics in Italy; Cocco [50] finds a role for income growth and income risk in Britain, and Ehrmann and Ziegelmeyer [82] find a role for income volatility in the Euro area.

estimated using a Mincer equation – see Brueckner and Follain [34], Dhillon et al. [73], Sa-Aadu and Sirmans [162], Paiella and Pozzolo [150], Coulibaly and Li [54], Cocco [50].

[6] Age dummies in Brueckner and Follain [34] and income in Paiella and Pozzolo [150] show little evidence although income growth data in Sa-Aadu and Sirmans [162] finds significant impact in the expected direction. Cocco [50] shows that higher income growth increases the likelihood of choosing alternative mortgage contracts relative to principal repayment mortgages.

[7] See also Sapienza et al. [164]. However, the experiments reported in Schubert [168] do not find gender-specific risk attitudes after controlling for economic conditions.

[8] See also Deakin et al. [63].

Using a unique dataset from over half a million mortgage applications by owner-occupiers in Australia between 2003-2008, we establish the dominance of mortgage cost in determining the product chosen, consistent with the existing literature for other markets. However, we shed new light on the role of borrower characteristics due to the rich detail in our complete individual, bank-verified loan application data – unlike existing studies we do not rely on interpolated or survey based measures. We find that income risk increases the probability that the household will take a product which reduces its exposure to payment variability, at least in the first part of the contract; mobility risk leads households to choose more flexible VRM products. The HM and SFRM products help households manage their income and wealth risk, but also allow constrained households to enter the housing market when they believe that potential rising house prices and rising inflation will result in a real wealth transfer from creditors to debtors. In addition, high LTV (LTV$>$ 80 percent) borrowers bear the interest rate risk of a VRM if they have high, unstable income (they are self-employed), have a strong mobility motive and are potentially financially experienced. These high LTV borrowers are more likely to prefer the certainty in SFRMs or HMs if they have low, unstable income or receive income stream support. Low LTV (LTV$\leq$ 60 percent) borrowers bear the interest rate risk of a VRM when they are older, wealthier and potentially financially experienced. However, low-LTV, risk-averse and constrained borrowers, who may be financially inexperienced, are more likely to choose away from VRMs. In our study, HM and SFRM products are shown to fill a niche of facilitating housing purchase for wealth constrained and consumers averse to income risk.

We find that the prudential capital requirements associated with on-balance-sheet mortgages interact with borrower characteristics to influence mortgage product choice. While mortgage product design manages interest rate risk and early-prepayment risk, LTVs determination manages default risk. The role of borrower characteristics is influenced by LTV; we show that income constrained borrowers show a greater preference for fixed-rate or discounted rate products when taking mortgages with high LTV, while borrowers with low LTVs take these products when they are more risk averse. Although borrowers are probably unaware of these effects, capital requirements for lenders influence mortgage choice via their interaction with borrower characteristics, and LTVs act as non-rate terms in mortgage contracts to discriminate and account for credit and prepayment risk variability across borrowers.

Section 5.2 provides some background on the Australian mortgage market and the existing predictions on mortgage choice determinants. The empirical methodology is given in Section 5.3, and Section 5.4 presents the data set. The results are discussed in Section 5.5, and the specific issues surrounding the effects of LTV ratios in Section 5.6. Section 5.7 discusses the robustness of our results and Section 5.8 concludes.

5.2 Background

5.2.1 Australian market

The Australian banking industry is highly concentrated, with the four largest banks holding more than 60 percent of owner-occupied loan approvals. Smaller banks have around 20 percent market share, credit unions and building societies less than 10 percent, and wholesale mortgage originators less than 10 percent; Davies [60]. This market has no government created structures to facilitate securitization. The share of total housing credit funded by securitization rose from 10 percent in 2000 to more than 20 percent in 2007, at which point issuance of residential mortgage-backed securities (RMBS) fell sharply with the onset of the global financial crisis. Almost all of this increase reflected the use of securitization as a funding vehicle for mortgage originators, credit unions, and smaller banks to access competitive funding; Debelle [66] and Debelle [67]. Major banks fund their mortgage debt predominantly through deposits and long- and short-term wholesale debt.

These funding strategies could be one of the reasons explaining Australia's mortgage product composition. Australian mortgages are predominantly a VRM product, while SFRM and HM represent a considerable share of the market; (respectively 60, 15 and 20 percent of our sample data). Full cost recovery fees apply to customers wishing to exit SFRM or HM contracts prior to the expiration of the fixed rate or discount period if market interest rates fall below the agreed rate. These two products reduce the initial payment burden for the consumer, but retain the longer term mortgage interest risk with the consumer, not with the financial institution. Other existing products include equity withdrawal mortgages, reverse mortgages, interest-only loans, shared-equity loans, low-documentation loans for borrowers who self-report their financial position, and forms of non-conforming loans for borrowers not meeting standard lending criteria. However,

these products represent only a small proportion of mortgage products in Australia. Debelle [68], reported that low-documentation loans never comprised more than 10 percent of housing loan approvals in Australia, and non-conforming loans never exceeded 2 percent of the total in data up to 2009.

As in many countries, taxation incentives exist in the housing market. The consumption services provided by owner-occupier homes are not taxable, and neither are capital gains on the sale of these properties. While mortgage interest payable by owner-occupiers is not tax deductible,[9] owners of dwellings purchased for investment purposes receive a deduction against wage and salary income for all associated expenses. Tax losses made in this way are not capped. Loans for owner-occupier housing comprise two thirds of banks' outstanding housing loans, and this proportion has shown very little variation in the decade which includes our sample period.[10] To further encourage home ownership, and in partial compensation for the introduction of the goods and service tax in 2000, there is a variety of grants and tax concessions offered to owner-occupiers by all levels of government to first-time home buyers; see Dungey et al. [77].[11]

5.2.2 Mortgage choice determinants: predictions in previous literature

Several theoretical studies examine the mortgage contract choice for borrowers. Campbell and Cocco [43] find that risk-averse households with a large mortgage, risky income, high default cost, or low moving probability tend to prefer FRMs. Meanwhile, households with smaller housing equity relative to income, more stable income, lower risk aversion, more lenient treatment in bankruptcy, and a higher probability of moving prefer ARMs. Piskorski and Tchistyi [153] model optimal mortgage contract under stochastic house price and income growth. They predict that mortgages with scheduled interest rate increases – HMs and SFRMs in our paper – should be more prevalent among borrowers with low income, low credit scores, low down payments (high LTV), and who live in locations with higher expected house price growth.[12]

[9] Bourassa [29] argues that the user cost of owner-occupier housing has a significant impact on tenure choice. In particular, he points out that the housing user cost depends on the loan-to-value ratio (LTV) because mortgage interest is not deductible in Australia.

[10] See ABS, Housing Finance Commitments, 560911.

[11] Outside of our sample period short-term variation in these concessions has also been used as an instrument of macroeconomic stabilization during the 2008-2009 global financial crisis.

[12] They also predict that the likelihood of mortgage modification should be an inverted U-shaped function of the borrowers LTV. Low-income borrowers with high LTV should be less likely to qualify for modification.

Higher interest rates in a mortgage contract predict a lower probability of taking that mortgage contract. However, increased cost of a FRM relative to an ARM/VRM will tend to favor choice of an ARM/VRM. To date Brueckner and Follain [34], Dhillon et al. [73], Phillips and VanderHoff [152], and Paiella and Pozzolo [150] support a positive effect for ARM choice over FRM when ARM interest rates are relatively lower. Other studies such as Amromin et al. [10] do not include these cost variables.

Higher LTVs have a higher credit risk associated for the lender;[13] a priori, we may speculate that lenders may prefer to reduce their interest rate risk and offer VRMs to borrowers, when the credit risk is high for high LTVs. However we observe that high LTV borrowers tend to choose away from VRMs, supporting the prediction in Piskorski and Tchistyi [153].

Borrowers facing expected housing price gains – higher house price inflation rate and an increase in house price expectations – may be willing to bear more interest rate risk; Amromin et al. [10] discover that when faced with the opportunity of taking a mortgage product which offers postponed loan repayments (defined as 'complex mortgages'), they prefer these complex mortgage products in a rapid house price growth environment.

Here we observe the choice between flexible VRMs and products which offer some level of certainty (a short-term fixed-rate or a discount on the variable-rate for a fixed period of time) but have higher associated prepayment costs. In this scenario, we expect consumers facing *income risks* – high unemployment rate, age, low income levels, certain occupational categories, self-employment – to prefer a product which reduces the variability of their payments. Borrowing constraints – low levels of liquid assets and net wealth, high levels of expenditure, age – are expected to influence households away from VRM products. Both HM and SFRM products are designed to reduce initial payments and may attract these households. Those facing *mobility risk* – measured as whether borrowers will move from their current residence – should choose products with the least penalty for change; in this market VRMs. Risk-averse borrowers – females, older borrowers, presence and age of children – may prefer the short-term certainty in SFRMs and HMs. The previous chapter indicated results in this direction.

We expect, in line with the results hypothesized in the literature, higher income, older applicants, or applicants with high mobility to be more likely to select a VRM product.

[13] See Von Furstenberg [184], Vandell [182], and Qi and Yang [155].

Females may be less likely than males to select a VRM, relating to the literature on lower financial literacy amongst women. First-time home buyers, who have been subject to a government promoted home ownership scheme during the sample period – see Dungey et al. [77] – may also be less likely to select a VRM, and take advantage of the certainty in SFRMs and HMs if they face income and wealth constraints. Low employment security, a younger applicant, and the presence of young children in the household are also expected to reduce the likelihood of selecting a VRM product.

Both HMs and SFRMs products are more appealing to households seeking less up-front risk. Households which are wealth or income constrained, but anticipate future improvements in their income, or indeed capital gains from house price inflation, may be attracted to these products. CM products offer short-term income and wealth risk management for constrained households.

5.3 Empirical specification

We consider the following index model.

$$y_i^* = \alpha + X_i'\beta + W_i'\delta + Z_i'\gamma + \varepsilon_i, \tag{5.1}$$

where at time of application, household i makes a decision to choose the mortgage product, y_i^* which best matches its risk profile given the mortgage cost variables faced by individual i at time of application, X_i, the macroeconomic and credit market conditions prevailing at time of application, W_i, and individual household characteristics, Z_i. The residual ε_i is assumed i.i.d normal. Note that estimation proceeds as a pooled regression, taking into account the time dimension by matching the time of application with market conditions at that time – this is not a panel estimation problem with repeated observations on the same individual, but rather has a time element in addition to cross-section dimension to the estimation problem.

However, there is not a continuum of mortgage products available, so that the observed behavior is the choice of either a VRM or the alternative (HM and SFRM products).

Consequently, define the dichotomous variable y_i as

$$y_i = \begin{cases} 1 \quad if \quad y_i^* \geq 0; & \text{i.e., borrower } i \text{ chooses a VRM} \\ 0 \quad if \quad y_i^* < 0; & \text{otherwise} \end{cases}$$

We are then interested in the probability of choosing a VRM, which can be expressed as a Probit:

$$P(y_i = 1|X, W, Z) = \Phi(\alpha + X_i'\beta + W_i'\delta + Z_i'\gamma) \tag{5.2}$$

where $\Phi(.)$ is the cumulative distribution of the standard normal ε_i.

Our maintained hypothesis is that choice of mortgage type is independent of the decision to apply for a mortgage. This assumption is dictated by our data which refer to mortgage applications only.[14] Paiella and Pozzolo [150] employ Italian household survey data to test the role of household characteristics on the choice to take a mortgage, and the choice between FRM and ARM; they test for sample-selection bias with a Heckman correction, and reject it. Ehrmann and Ziegelmeyer [82] arrive at a similar conclusion for the Euro area.

We estimate the interest rate spread between alternative mortgages available to the householder at the time of application correcting for sample selection bias using 2SLS following Brueckner and Follain [34];[15]

$$RATE_i^{HM} = V_i'^{HM} B^{HM} + u_i^{HM} \tag{5.3}$$

$$RATE_i^{SFRM} = V_i'^{SFRM} B^{SFRM} + u_i^{SFRM} \tag{5.4}$$

$$RATE_i^{VRM} = V_i'^{VRM} B^{VRM} + u_i^{VRM} \tag{5.5}$$

where V^{HM}, V^{SFRM}, V^{VRM} are vectors containing the determinants of the interest rates on HM, SFRM and VRM products respectively, and include interest rates across

[14] Longitudinal surveys such as the Household, Income and Labour Dynamics in Australia (HILDA) survey offer the potential to examine this issues, but questions on the type of mortgage were first asked in Wave 10 of the survey, conducted in late 2010, which is after the global financial crisis, and outside our sample period. Wave 2 of the survey, conducted in 2002, was used by Kohler and Rossiter [123] to investigate how family characteristics impacted leverage ratios for home-buyers. They found that when estimating a Heckman selection model, there was no selection effect.

[15] See also Paiella and Pozzolo [150], Ehrmann and Ziegelmeyer [82], Lee and Trost [137].

the maturity structure and regional dummies.[16] B^{HM}, B^{SFRM} and B^{VRM} are corresponding loading vectors, and the errors u^{HM}, u^{SFRM} and u^{VRM} are i.i.d normal. We predict the interest rate differential as the difference between these fitted values. In this way we allow for the differences between three products in our model – denoting the spread between the SFRM and VRM as '$RATEDIFF$' and the difference between the VRM and HM as the '$Discount$'.;

$$\widehat{RATEDIFF}_i = V_i'^{SFRM}\widehat{B}^{SFRM} - V_i'^{VRM}\widehat{B}^{VRM}. \tag{5.6}$$

$$\widehat{Discount}_i = V_i'^{VRM}\widehat{B}^{VRM} - V_i'^{HM}\widehat{B}^{HM}. \tag{5.7}$$

These fitted interest rate differentials ($\widehat{RATEDIFF}$ and $\widehat{Discount}$) are used in estimation of the probit model.

5.4 Loan-level data

The underlying data in this study refer to bank-originated mortgages issued to applicants for owner-occupier housing, including applications for the refinancing of existing home loans. The initial data set comprises 617,868 owner-occupier home loan applications for the period January 2003 to August 2008 – thus avoiding the global financial crisis – for seven States or Territories of Australia.[17] Of these, 41.7 percent are CM contracts, and the remainder are VRMs.

Variable definitions are provided in Table A.1 in Appendix A, while Table 5.1 shows descriptive statistics for the mortgage cost and borrower characteristics variables in the database – all monetary variables are reported in real 2006Q1 Australian dollar values. The mean size of the VRM contract is over AUD $227,000, the HM is over AUD $165,000 and the SFRM is over AUD $189,000. Initial mean monthly repayments for VRMs exceed those for other mortgage products, reflecting the higher value of the VRM mortgages. The mean term for each mortgage type is the same at 30 years, noting that

[16] The interest rates used are the 90 day-bank bill, 3-month OIS, 3-month term deposit, 3-year term deposit, and 3-year Australian Government bond rate. Regional dummies are common to each specification. In each case the selection bias coefficient is positive and significant. These results are available on request.

[17] These are Australian Capital Territory (ACT), New South Wales (NSW), Queensland (QLD), South Australia (SA), Tasmania (TAS), Victoria (VIC) and Western Australia (WA). The Northern Territory (NT) is excluded as the bank which provided our data has no branches there, although there are some applications from NT residents or for property in the NT. The majority of applications are recorded for NSW, QLD and VIC consistent with the population distribution in Australia.

we have no information on the term of any honeymoon arrangements or how long an initial fixed rate period may be in the dataset. The mean HM rate is below that of the VRM and SFRM. The mean LTV in the dataset for both contracts is similar to the average of 67 percent recorded for the Australian market in September 2006 by the Australian Prudential Regulatory Authority (APRA).[18]

In terms of household characteristics, the mean VRM applicant is 49 years old, has monthly gross income of AUD $7,432 (AUD $89,184 per annum), net wealth at time of application (Household surplus) of AUD $420,895, and liquid assets over AUD $56,000. The VRM applicants have been clients of the bank for 2 years longer than other applicants, and have slightly higher credit scores. The mean borrower for both a HM and a SFRM is 38 years old, with no dependents (where dependents are present the average age of the youngest child is 5 years), has mean gross monthly income 10 to 28 percent lower – AUD $5,423 (AUD $65,076 per annum) for HMs and AUD $6,709 (AUD $80,508 per annum) for SFRMs – and mean net wealth more than 20 percent lower than the mean VRM borrower – AUD $311,445 for HMs and $331,760 for SFRMs.

Table 5.1 also shows how the descriptive statistics for the three mortgage products varies across LTV range. The most noticeable differences are observed for loan amount, net wealth and liquid assets, as expected. Average gross monthly income is largest for borrowers with LTVs between 60 and 80 percent, which accompanies an incrementing debt-servicing ratio (DSR) across LTVs ranges.

As shown in equation (5.2) the explanatory variables are divided into three groups: mortgage costs X, market conditions W, and borrower characteristics Z. Table 5.2 shows the estimation results for (5.2), with bias selection correction. Exact definitions of all variables are given in Appendix A.

The mortgage costs variables include: the monthly average VRM interest rate; the interest differential between SFRM and VRM mortgages; the discount on the HM; a dummy to represent large loans (over AUD $500,000); and the loan-to-value ratio (LTV). We also include an interaction variable between the interest rate differential and the borrower's income.

Market conditions variables include: unemployment, inflation and house price inflation rates, and the net assistance provided by Federal and State governments to first-time

[18] APRA (2007), 'ADI housing lending', APRA Insight, Issue 1.

TABLE 5.1: Summary Statistics by LTV

	$LTV \leq 60\%$			$60\% < LTV \leq 80\%$			$LTV > 80\%$			Total		
Variable	VRM	HM	SFRM	VRM	HM	SFRM	VRM	HM	SFRM	VRM	HM	SFRM
Loan	$171,045	$137,305	$148,689	$267,139	$183,000	$203,950	$271,557	$193,312	$227,372	$227,046	$165,427	$189101
	(130,385)	(78,776)	(88,299)	(156,904)	(92,279)	(102,591)	(126,446)	(83,376)	(94,293)	(149,765)	(88,680)	(100,924)
Repayment	$1,207	$937	$1,084	$1,808	$1,203	$1,437	$1,863	$1,283	$1,614	$1,560	$1,104	$1,348
	(902)	(540)	(645)	(1,154)	(645)	(785)	(949)	(625)	(742)	(1,068)	(617)	(757)
Interest rate	7.24%	6.76%	7.34%	7.09%	6.60%	7.30%	7.09%	6.60%	7.40%	7.16%	6.67%	7.34%
	(0.75)	(0.94)	(0.76)	(0.73)	(0.88)	(0.76)	(0.73)	(0.95)	(0.78)	(0.74)	(0.92)	(0.77)
DSR	38.68%	36.29%	40.56%	49.95%	42.73%	48.44%	52.62%	45.34%	51.24%	45.56%	40.45%	46.21%
	(17.91)	(14.59)	(15.46)	(17.30)	(14.45)	(15.11)	(15.34)	(14.01)	(14.05)	(18.29)	(14.90)	(15.64)
LTV	42.01%	43.73%	44.52%	72.78%	72.47%	72.75%	90.55%	90.57%	90.82%	62.34%	63.40%	66.49%
	(14.51)	(13.02)	(12.71)	(6.70)	(6.66)	(6.52)	(4.22)	(4.23)	(4.17)	(21.22)	(20.39)	(19.99)
Monthly income	$6,853	$5,300	$6,268	$7,976	$5,580	$7,049	$7,517	$5,355	$6,780	$7,432	$5,423	$6,709
	(3,717)	(2,651)	(3,378)	(3,884)	(2,613)	(3,536)	(3,234)	(2,211)	(3,004)	(3,760)	(2,569)	(3,387)
Living expenditure	$1,346	$1,276	$1,300	$1,363	$1,263	$1,307	$1,263	$1,183	$1,189	$1,341	$1,254	$1,279
	(616)	(753)	(569)	(610)	(586)	(542)	(548)	(607)	(514)	(605)	(666)	(548)
Net wealth	$544,764	$427,875	$459,351	$384,390	$267,953	$313,493	$170,289	$126,214	$155,490	$420,895	$311,445	331,760
	(386,268)	(311,093)	(339,545)	(321,166)	(234,896)	(265,979)	(167,213)	(132,891)	(160,295)	(357,673)	(280,593)	(299,660)
Liquid assets	$62,389	$43,529	$53,581	$57,944	$28,935	$45,393	$34,287	$19,482	$25,806	$56,349	$33,497	$44,087
	(97,930)	(78,111)	(88,568)	(83,948)	(49,532)	(70,653)	(42,944)	(27,308)	(36,264)	(86,303)	(61,563)	(72,988)
Liabilities	$4,135	$3,775	$3,810	$4,486	$4,029	$4,070	$3,539	$3,011	$2,777	$4,148	$3,748	$3,695
	(9,413)	(8,818)	(9,646)	(9,918)	(8,881)	(9,554)	(7,041)	(6,172)	(5,827)	(9,336)	(8,460)	(8,927)
N	130,119	56,702	31,989	133,212	52,709	37,304	45,445	23,317	19,293	308,776	132,728	88,586

Note. Means and (Standard Deviations) , Jan 2003 - Aug 2008. All monetary values are in 2006 Q1 AUD $.

home buyers, obtained from Dungey et al. [77]. Consumer sentiment on housing market conditions is captured through changes in the dwelling index collected by Westpac-Melbourne Institute. To control for competition between lenders, given that we only have one bank provider, we include a dummy indicating whether the Bank was offering the lowest market interest rate for SFRM at time of application.

The borrower characteristics in our data set are particularly rich. One group of variables concerns household structure and demographics, and includes borrower age, gender, marital status, number of dependent children, and the presence of very young children. Loan servicing capacity is captured by income, expenditure, occupation and employment status. Additional information on their financial position is provided by variables on net wealth, liquid assets, and short-term liabilities. Evidence of any ongoing relationship with the bank is captured by the number of years as a client, and the number of current accounts and credit facilities. As a proxy for mobility we use a binary dummy to indicate whether the applicant will change post-code (suburb) from their address at time of mortgage application and the address of the new property.[19]

5.5 Empirical results

The baseline applicant is a 40-year-old single salary-earning male without a co-applicant, with no dependents, who is not a first-time home buyer, with a loan under AUD $500,000.

Table 5.2 presents the average marginal effects of the probit estimation. Column (1) reports the results for the whole owner-occupiers sample, using interest rate differentials ($\widehat{RATEDIFF}$ and $\widehat{Discount}$) built from the fitted rates from equations (5.3)-(5.5) with selection bias correction.[20]

We proceed in the following sub-sections to discuss the effect of mortgage cost variables and market conditions and, separately, borrower characteristics; see column (1) of Table 5.2.

[19] We also used the time in years spent at current and previous addresses to proxy for mobility, however results were empirically weaker.

[20] We also tested results where the interest rate differential are constructed from the monthly averages of the interest rates for each contract as reported by the bank.

5.5.1 Mortgage costs and market conditions

In line with the existing literature, the results in Table 5.2 support the importance of the mortgage terms and costs in mortgage product choice. A widening range between the SFRM and the VRM rates ($\widehat{RATEDIFF}$) is expected to increase the probability of VRM choice as this becomes the relatively cheaper product. This is reflected in our results, where an increase in the margin of the SFRM over the VRM of 100 basis points leads to a 55 percent increase in the probability of choosing a VRM product. Clearly households are very sensitive to relative interest rates in choosing their financing product. However, when we control for a potential non-linearity in the spread between SFRM and VRM related to income ($\widehat{RATEDIFF} \times$ Income), our results suggest that borrowers with higher income are less sensitive to a widening spread between the rates of these two contracts. The discount offered on a HM contract ($\widehat{Discount}$) is less important in magnitude, however it is statistically significant and has the expected sign. For a 100 basis point rise in the discount between a VRM and a HM there is a 4.7 percent fall in the probability of observing a VRM product choice.

In addition, a 100 basis point increase in the VRM interest rate decreases the probability of taking a VRM by 9.4 percent. For example, the predicted probability of taking a VRM when the prevailing VRM rate is 6.9 percent (as in June 2005) is 61 percent; while when the prevailing rate is 9 percent (as in August 2008) the predicted probability is 41 percent.

Loans of greater than AUD $500,000 attract a further marginal increased probability of selecting VRM of about 22 percent. To put this in the Australian context, it is useful to know that the median (2006) house price in Sydney was $470,000.[21]

Loan ratios also affect mortgage choice. As default risk increases through higher loan-to-value ratios (LTV), households are less likely to choose a VRM over an alternative which offers some level of certainty.[22] A LTV below 80 percent attracts a 50 percent discount on Basel capital requirements on lenders. At very high LTV, say 100 percent, the probability of observing a VRM is 51 percent, but at 80 percent LTV the probability of observing a VRM is 56 percent. Borrowers with low equity in their residential property

[21] ABS House Price Indexes: Eight Capital Cities, June 2013: Catalogue 6416.02.

[22] Capone Jr and Cunningham [45] argue that borrowers with less initial equity (and higher LTVs) are more risk averse and less apt to select an ARM relative to a FRM.

prefer the initial low and certain payments in HMs and SFRMs. We return to the issue of LTVs in Section 5.6.

Macroeconomic conditions are often included as controls in mortgage choice studies, as they are presumed to provide information to both borrowers and lenders about expectations of future states of the economy. Commonly chosen indicators include the unemployment rate, house price inflation and the slope of the yield curve or inflation expectations; see for example Dhillon et al. [73], Paiella and Pozzolo [150], Amromin et al. [10], Ehrmann and Ziegelmeyer [82].

Our results support the statistical significance of market conditions, although the effects are sometimes not large. For instance, a one percentage point rise in the unemployment rate – representing income risk – decreases the probability of a VRM by under 6 percent, and a one percentage point increase in the inflation rate – representing potential future interest rate risk – decreases the likelihood of VRM choice by only 1.1 percent.

Borrowers' response to potential home equity gains is strongly reflected in the increased probability of observing a VRM as consumer sentiment around a dwelling index derived from the Westpac-Melbourne Institute survey improves. An increase in this buying sentiment index increases the probability of taking a VRM by 22 percent; the incentive provided by potential capital gains outweighs the savings from delayed repayments in a HM or SFRM. This result dominates the effect of observed house price inflation.[23]

Over the sample period the Australian government has provided a number of programs to boost home ownership for first-time home buyers (FHBs). Using the measure of net assistance from Dungey et al. [77], we find that increased support to FHBs leads to a small decrease in the probability of these borrowers taking a VRM in favor of the alternatives, however the effect is statistically insignificant.

Given that our data are provided by one major bank, albeit with national representation, we also control for competition in the market by observing whether this bank is offering the lowest SFRM interest rate in the market on the month of application. When the bank is offering the lowest interest rate on a SFRM contract relative to the other banks, borrowers are more likely to take a VRM contract, but the effect is statistically insignificant.

[23]The correlation coefficient between the change in the dwelling index and the house price inflation rate is -0.66.

Our study excludes a number of interest rate control variables included in previous literature; in particular the spread between the long-term government bond rate and short-term bill rate, and the central bank official target rate.[24] The VRM rate is closely related to the official short-term rate and the SFRM rate closely follows the market rate on the 3-year Australian Government bond.[25] As these yields have been used to predict the rates in equations (5.3)-(5.5), they are omitted from the probit specification.

5.5.2 Borrower characteristics and risk categories

In our uniquely detailed and bank-verified data, we can identify significant effects of most borrower characteristics, which when classified into income, wealth and mobility risk groupings, provide evidence consistent with the existing theoretical literature. For example, studies such as Brueckner and Follain [34] find evidence of mobility risk only, while Cocco [50] and Ehrmann and Ziegelmeyer [82] find evidence of income risk only. Here, we find all risk categories are statistically relevant.[26]

Income risk management is captured by 7 variables: real gross income level, the unemployment rate, self-employment status, marriage, presence of a co-borrower, occupational categories and age. The marginal effects of income, marriage, co-borrower and occupational category are individually quite small, as reported in column (1) of Table 5.2. The uncertainty associated with higher unemployment environments provides the largest effect – a 5.9 percent decrease in the probability of a VRM associated with a one percentage point increase in the unemployment rate. Younger borrowers, who are at the beginning of their income life-cycle, have a lower probability of choosing a VRM, despite potential (unmeasured) future income growth. Although the individual income

[24] Dhillon et al. [73], Sa-Aadu and Sirmans [162], and Coulibaly and Li [54] include the yield spread as an explanatory variable together with the interest rate spread. Koijen et al. [125] find that the yield spread is weakly related to the share of ARMs; note that the definition of ARM in Koijen et al. [125] for the U.S. is equivalent to our definition of CM in Australia.

[25] We thank market participants and regulators for feedback on this point.

[26] Dhillon et al. [73] find some evidence of the negative effect of marital status and presence of a co-borrower on the probability of taking an ARM, contradictory to the expectation that a spouse or a co-borrower represents an additional income earner to spread the income risk in favor of an ARM. Brueckner and Follain [34] find that higher income borrowers are more likely to take an ARM than lower income borrowers. Coulibaly and Li [54] find that income volatility decreases the likelihood of taking an ARM, while a college degree and mobility increases it. Paiella and Pozzolo [150] find that only age, the presence of children and living expenditure can explain mortgage product choice from a set of fourteen variables representing borrower characteristics in Italy. Amromin et al. [10] find that income, college and youth are good determinants of mortgage choice. Cocco [50] finds evidence for education, income growth and income risk for UK survey panel data. Our CM products have some similar characteristics to the ARMs studied in the U.S. empirical work.

risk management variables have relatively small significant effects, combining them suggests that a borrower over 60 years old (2.6 percent) with higher than average income (1.9 percent), who has a professional occupational category (4.2 percent), is married (1 percent) and has a co-borrower (0.8 percent), and faces low unemployment risk (5.9 percent) will be 16.4 percent more likely to choose a VRM than the benchmark borrower, as theory predicts.[27] In contrast, a young, single borrower with low income, no co-borrower, in an unskilled trade occupation, and in a high unemployment rate environment is over 15.6 percent more likely to take a HM or SFRM product than the benchmark borrower.[28] Employment status as self-employed increases the probability of taking a VRM, consistent with preference for no prepayment costs under volatile income.[29]

Although income risk may be low, *borrowing constraints* may be binding and restrict the contract choice. To capture borrowing constraints we consider real income level and age, living expenditure, presence of dependent children, and the number of credit facilities.[30] Our results show small, but statistically significant effects consistent with theory on borrowing constraints in the following ways. Younger applicants tend to choose a CM product, as do those with young children and those with higher living expenditure. While all individuals are sensitive to the interest rate differential between products, this is particularly evident for low income borrowers – the interaction term between $RATEDIFF$ and income level is significantly negative. As an exemplar of this category, we calculate that a borrower under 30 years old, with children under 5 years old, with real gross monthly income $1,000 lower than average, and monthly living expenses $1,000 more than average, is 8.2 percent more likely to take a HM or a SFRM than a VRM. However, the most important of the influences they face in choosing their mortgage contract is seeking the lowest interest rate.

[27] For example, this profile matches the 'Seniors' cluster (3) described in the previous chapter.

[28] This result seems to contrast with the conclusion in Cocco [50], who finds that higher income risks decrease the probability of alternative mortgage products (AMPs). However, in Cocco [50] AMPs are compared to principal repayment mortgages, while in our paper HMs, SFRMs and VRMs are both principal repayment mortgages with different interest rate fixity.

[29] Only when the estimation is performed using the restricted variable set of borrower characteristics Z only, the effects of both self-employment and small business proprietor status are significant. The correlation coefficient between self-employment status and small business proprietor status is 0.57.

[30] La Cava and Simon [127] show that older borrowers, a large family size, renter status, unemployed status, females, disabled, low income level, low dwelling value, high income from government benefits and few credit cards result in a higher probability of cash-constraint.

We use variables from both market conditions and borrower characteristics to capture *wealth risk* management. High net wealth and liquid assets, together with low short-term liabilities, suggest that borrowers could repay the mortgage sooner and have lower default risk; these effects are statistically significant, but without economic impact. The presence of a co-borrower gives a bigger pool of wealth to the household, and diminishes default risk; again the effect is relatively small. However, potential capital gains through housing exercise a relatively large impact. Borrowers expecting equity growth on their property are significantly more likely to hold the interest rate risk of a VRM in order to access the expected equity gain.[31]

In line with existing results on *mobility risk*, applicants who are purchasing a property in a different postcode to their current address, whom we identify as more mobile, are 3.1 percent more likely to take a VRM. This result reflects that HMs and SFRMs have higher associated prepayment penalties in Australia than VRMs, however we expect the mobility motive to be less relevant in Australia relative to the U.S. labor market.

A number of other interesting results are apparent. The literature suggests that females, older individuals, and those with dependent children tend to be more risk averse; and these effects are supported in our results. Our model predicts that a young female borrower with 2 children under 5 years old is 8.9 percent more likely to take a CM than a male borrower with no dependents. However, older borrowers are more likely to choose VRMs than the benchmark borrower in his forties. Moreover, females and first-time home buyers are usually less financially experienced. We identify borrowers with several credit accounts and credit facilities, and who have a long history with the bank (5 more years), as potentially more financially experienced, and find that these effects operate to increase the probability of choosing a VRM product by 5.3 percent.

The results presented here are a powerful validation of the theoretically expected signs of borrower characteristics on mortgage choice. For the first time, a relatively complete set of borrower characteristics has been available to examine mortgage product choice. This database has high quality income and household characteristic information, and has not had to rely on imputed or survey data to describe the household. Nor, in the Australian market, are there institutional arrangements which interfere with our observation of the risk allocation between household and financial institution in mortgage transactions.

[31] In the Australian market, borrowers who wish to upgrade to a new property by taking advantage of equity gain, face prepayment penalties in CM products as well as transaction costs.

The direct consequence has been that we are able to show that as anticipated; income risk increases the probability that the household will choose a product which reduces its exposure to payment variability, at least in the first part of the contract; mobility risk leads households to choose more products with low early-repayment costs – as VRMs in the Australian market. Products with some level of certainty in the repayment and high early repayment fees help households manage their income and wealth risk, but also allow constrained households to enter the housing market when they believe that potential rising house prices and rising inflation will result in a real wealth transfer from creditors to debtors.

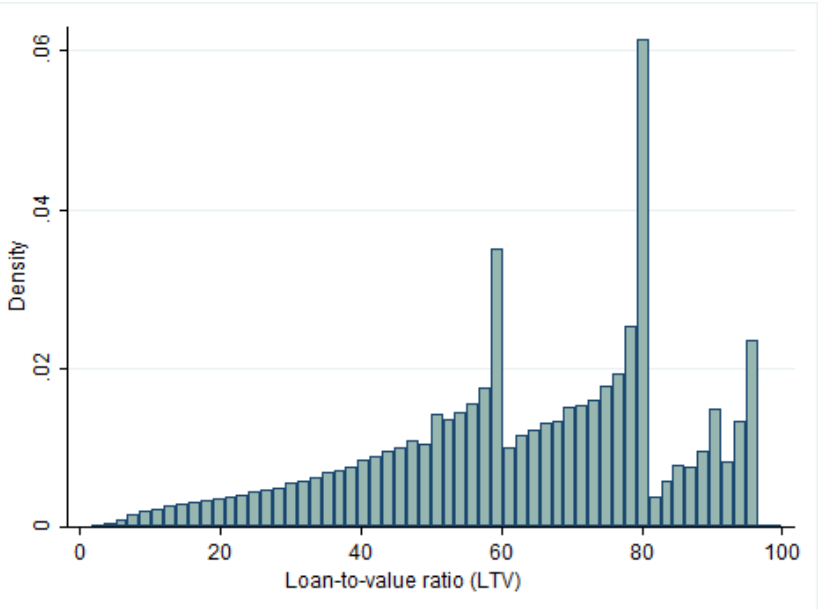
5.6 Loan-to-valuation ratios (LTV)

Although there are many papers discussing the impact of Basel capital requirements on mortgage providers,[32] we are not aware of previous direct evidence on the outcomes of these requirements for individual mortgage applicants. During the sample period, Australian mortgages attracted a concessional risk weight of 50 percent when LTV was less than 80 percent, or 60 percent for low-documentation loans.[33] Loans which did not meet these criteria only qualified for the capital requirement discount if they were fully insured – which in the Australian context requires the loan applicant to take a private insurance contract which pays directly to the bank in the event of default. While our database does not specifically distinguish low-documentation loans or loans with mortgage insurance, Figure 5.1 reveals the bimodal distribution of the LTV data for the contract applications, precisely around the 60 and 80 percent Basel capital cut-off points; a third mode occurs at 95 percent.

[32] See for example Calem and LaCour-Little [40] and Allen [6].

[33] During most of our sample period, capital requirements in Australia followed the set of 'Basel I' capital accords implemented in 1988; see 'Banking (prudential standards) determination No. 2 of 2005. References in APS 112 to AGN 112.1, Banking Act 1959', http://www.comlaw.gov.au/Details/F2005L02873. In January 2008, APRA implemented the 'Basel II' capital requirements in the Australian market. The new requirements, announced in 2007, allow authorized deposit-taking institutions (ADIs) to calculate their risk-weighted assets (RWA) following a 'standarized approach' or an internally generated 'advanced approach'. In general, smaller banks and building societies use the 'standarized' approach, which sets risk weights prescribed by APRA and based on LTVs and mortgage insurance; see 'Prudential Standard APS 112. Capital adequacy: Standarised approach to credit risk', page 20, http://www.apra.gov.au/adi/prudentialframework/documents/aps-112-12-12-07-final.pdf. The four major banks, along with other banks, use the Internal Ratings-based approach (IRB) which involve the internal estimation of probability of default (PD), loss given default (LGD) and exposure at default (EAD); see 'Regulation impact statement: adoption of the Basel II capital framework in Australia', http://www.apra.gov.au/adi/Documents/Final-Basel-II-RIS.pdf. Although the transition

FIGURE 5.1: Distribution of Loan-to-Value Ratios (LTVs).



High LTV ratios at origination are known to be associated with higher default risk for the lender; see Von Furstenberg [184], Vandell [182], and Qi and Yang [155].[34] In addition, there is some evidence of endogeneity for LTV with respect to borrowers' income and wealth in the Netherlands in Cunha et al. [56].[35]

Overall, the benchmark borrower with LTV over 80 percent is 3.8 percent less likely to take a VRM than the benchmark borrower with an LTV between 60-80 percent. Similarly, compared to this borrower, the benchmark borrower with low LTV is 1.2 percent more likely to take a VRM. We confirm the prediction in Piskorski and Tchistyi [153] that mortgages with scheduled interest rate increases (HMs and SFRMs) should be more prevalent among low down payments (high LTV) borrowers.

We repeat our investigation of mortgage choice distinguishing three subsamples of LTVs: LTV$\leq$ 60%, 60% <LTV$\leq$ 80%, and LTV> 80%. Columns (2), (3), and (4) in Table 5.2 report the results for these sub-samples.[36] The largest difference occurs in response to the differential between the SFRM and VRM interest rates ($RATEDIFF$). High LTV borrowers are 86 percent more likely to take a VRM when SFRMs become relatively

from 'Basel I' to 'Basel II' occurred at the end of our sample period, we have checked our results for the sample periods Jan2003-Sep2007 and Jan2003-Feb2008 and obtain similar results.

[34]Campbell and Dietrich [44] and Calem and LaCour-Little [40] find this initial LTV is less important than the current LTV ratio, and indeed that initial LTV may be negatively associated with default risk.

[35]We address this issue in the following chapter.

[36]Coefficients which are not statistically different across sub-samples are reported in red color.

more expensive, while low LTV borrowers are only 33 percent more likely to take a VRM under this scenario.[37] Borrowers with high LTVs are more likely to bear the interest rate risk in a VRM when VRM interest rates are comparatively cheaper than SFRM interest rates; their mortgage product selection is strongly determined by a cost motive. This result is also supported by the stronger effect of a 100 basis point increase in the average VRM interest rates on borrowers taking mortgages with high LTVs.

Interestingly, when the discount on HMs rises, high LTV borrowers are least likely to take VRMs – probably selecting the cheaper HM contract – but low LTV borrowers are more likely to take VRMs.

As in the previous section, we find that borrowers with loans over AUD $500,000, who believe it is a good time to purchase a dwelling, who tend to be professionals or in a management position, and with high levels of income, liquid assets (and several credit account and credit facilities) are more likely to take a VRM, whether they take high or low LTVs. Moreover, (female) borrowers under 30 years old, with lower income, who have a service, agricultural or skilled- or unskilled-trade related occupation are more likely to take a HMs or SFRMs, regardless of their LTV.

The examplar households from the previous section illustrate the effect of the LTV categories on the role of borrower characteristics in mortgage choice. In the full sample results, a higher income senior borrower, from a professional occupation category, who is married, has a co-borrower, and faces low unemployment risk was 16.4 percent more likely to choose a VRM than the benchmark. However, once we adjust for LTV category – which means that the benchmark borrower is also in that LTV category – borrowers with low LTV are 16.3 percent more likely to choose a VRM than the benchmark borrower in their LTV category. In the over 80 percent LTV category, they are only 10.6 percent more likely to choose a VRM than the average borrower with a greater than 80 percent LTV.

The second exemplar is a borrower under 30 years old, with children under 5 years old, gross monthly income $1,000 lower than average, and living expenses $1,000 higher than average who was 8.2 percent less likely to choose a VRM than the sample benchmark applicant. When compared with the benchmark borrower in the less than 60 percent

[37] Recall, however, that in each of the categories, the comparisons of effects are now relative to the benchmark 40 year old, single salary-earning male borrower, with no co-borrower, who is not buying his first property, with a loan of under AUD $500,000, and in the same LTV category.

LTV category, these borrowers are 10.7 percent less likely to choose a VRM product, but this drops to only 3.9 percent less likely in the over 80 percent LTV category.

The results of this section show that we can identify, by their borrower characteristics, a group of applicants, who when faced with high LTV loans choose away from VRMs in order to lower their interest rate risk exposure. Other borrowers with high LTVs may be prepared to hold more interest rate risk.

Most importantly, we can distinguish particular patterns in high and low LTV borrowers. Factors such as age, marital status, number of dependents and wealth, short-term liabilities and living expenses do not play a role in determining mortgage choice for high LTV borrowers; this is not surprising when considering that probably high LTV borrowers are less risk-averse and more wealth constraint than borrowers taking lower LTVs. Similarly, variables such as mobility, government net assistance for FHBs, and self-employment status are not relevant considerations for borrowers with low LTVs when choosing a mortgage product.

On the one hand, borrowers with high LTVs (and low equity in their property) – which represent higher default risk for the lender – are more likely to take VRMs when they are self-employed, have high income, and have a strong mobility motive. These results suggest that borrowers taking high LTV loans choose VRMs when they are mobile, have high-income, and most likely are non-risk averse and financially experienced mortgage applicants.

Meanwhile, borrowers with equity in their property (and low LTV) are more likely to bear the interest rate risk of a VRM if they are over 60 years old, married, have a co-borrower, have high level of wealth, are unemployed or have spent more time as clients of the bank. Therefore, borrowers taking low LTV VRMs are older, high income and wealth applicants – less mobile, more risk averse and less financially savvy – who may be getting a new home or renovating.

On the other hand, borrowers accessing high LTVs are more likely to take HMs or SFRMs when they apply with a co-borrower or when they receive first-time home buyers' government support, which reflect mainly income constraint. However, borrowers with low LTV take HMs or SFRMs when they are under 40 years old, have dependents, and

have high living expenditure and high short-term liabilities, which reflect mainly risk aversion and financial constraints.

Interestingly, those applicants with co-borrowers are more likely to take a VRM when they have low LTV loan, but are more likely to take away from VRMs with a high LTV relative to their respective benchmarks. This result suggests that borrowers with low default risk (low LTV) may be more prepared to bear the interest rate risk of a VRM when they can combine their income with other income earners.

First-time home buyers are less likely to take a VRM if they have low LTVs, however when holding high LTV loans they are more likely to take VRMs; this result can be seen from the lenders' perspective as a trade-off between credit risk and interest rate risk for first-time home buyers.

The results highlight the potential importance of LTV, and its relationship with prudential capital rules. While the borrowers may be unaware of it, the prudential regulations around capital requirements on lenders are demonstrably interacting with the borrower characteristics in influencing mortgage product choice.

5.7 Robustness

The results presented in this paper are robust against an extensive set of alternative specifications. We calculated the average interest rate on contracts using daily rather than monthly data, we used the average market spreads between interest rates on these products rather than those reported by the bank. We have investigated the role of other non-reported explanatory variables such as: the RBA target interest rate, yield spread between long- and short-term bonds/bills, expected inflation, monthly real mortgage repayments, age as a continuous variable, experience represented by quadratic age term, net real monthly income, time at current and previous addresses, and time at current and previous employments. State levels of unemployment, inflation and housing price inflation rates did not provide further information than the national levels. A hybrid log and level specification, using log transformations for real wealth variables, or a log specification for all real monetary values, were also qualitatively the same. Finally, we find that market condition variables are more informative than simply substituting for these with yearly or monthly dummies for fixed time effects.

Our specification predicts correctly 65.2 percent of the cases. The sensitivity (probability of predicting a VRM on borrowers who take a VRM) is 80.4 percent, while the specificity (probability of predicting a non-VRMs on borrowers who take a HMs or SFRMs) is 43.9 percent. We checked the consistency of our preferred specification by estimating the probability of taking a SFRM rather than a VRM, and used LPM, Probit and Logit models, and we obtain qualitatively similar results.

In summary, subject to this wide-range of robustness checks, the results of the paper are maintained. Borrower characteristics are significant explanators of mortgage choice. Importantly, the prudential regulatory capital requirements on LTV ratios resulting from Basel II are shown to have a significant effect on the role borrower characteristics play in influencing household mortgage choice.

5.8 Conclusion

Borrower characteristics should be useful indicators of the risk profiles of mortgage applicants – in theory identifying income, wealth and mobility risk from observable features. Existing empirical evidence for this, however, is mixed and inconclusive. In a unique proprietary dataset for an economy where banks fund the majority of mortgages, and this debt is held on-balance-sheet, we now produce evidence aligned with theoretical predictions about the impact of borrower characteristics on mortgage product choice. Our Australian database consists of verified financial and demographic information on over half-a-million mortgage applications for variable-rate mortgages (VRM), short-term fixed-rate mortgages (SFRMs) and discounted variable-rate mortgages (HMs) products.

HM and SFRM products lie between the VRM and the standard long-term FRM most often considered in the literature – but which do not exist in Australia. They offer delayed repayments and attract borrowers seeking lower short-run payment commitments. We confirm the effects anticipated in the theoretical literature, weakly empirically confirmed; risk averse borrowers facing income and wealth constraints are more likely to prefer products which reduce their initial repayments or offer repayment certainty, that is non-VRMs in the Australian context. In contrast, those facing mobility risk and high unstable income are more likely to prefer the flexibility in a VRM. While these borrower effects are significant, we confirm the findings elsewhere that mortgage costs are the

dominant determinant of product choice. A typical young borrower, with dependents and high expenditure, have increased probability of choosing a HM or SFRM, whereas an older, higher income borrower with evidence of mobility has increased probability of choosing a VRM.

Even more strikingly, we are able to exploit the effects of the LTV ratios defined by Basel capital adequacy requirements which particularly affect lenders who retain mortgage debt on-balance-sheet. Mortgages with LTV of below 80 percent (and 60 percent for low-documentation contracts) attract a 50 percent discount on Basel capital requirements, and the LTVs in our database are multi-modally distributed around these thresholds.

High LTV (LTV>80 percent) borrowers are even more likely to seek the lowest interest rate product, relative to the benchmark applicant taking a mortgage with a LTV between 60 and 80 percent. The mobility motive for seeking a VRM remains dominant, even when the applicant faces a high LTV. High credit risk borrowers (high LTV) bear the interest rate risk of a VRM if they have high income – self-employed –, have a strong mobility motive and are potentially financially savvy. However, these high LTV borrowers are more likely to make use of the certainty in SFRMs or HMs if they have low, unstable income or receive income stream support from the government first-time buyer assistance scheme[38] or from a co-borrower. Risk aversion – represented by marital status, presence of dependents, and age – together with wealth are not determinant factors in the mortgage product choice of high LTV borrowers, suggesting that borrowers with high LTVs tend not to be particularly risk averse and wealthy.

Low LTV (LTV$\leq$60 percent) borrowers are less sensitive to mortgage relative costs than the benchmark applicant. They bear the interest rate risk of a VRM when they are older and wealthier. However, low LTV risk averse and constraint borrowers, who may be financially inexperienced, are more likely to take HMs or SFRMs. The mobility motive is not a determinant of the mortgage product choice for low LTV borrowers.

We conclude that the mortgage type chosen and the LTV agreed behave as non-rate terms in mortgage contracts to discriminate and account for credit and prepayment risk variability across borrowers. Based on the evidence presented in this chapter for the effect of LTVs on the borrower characteristics determining mortgage choice, we extend

[38]Before the impact of the global financial crisis in Australia, mortgage lenders tended to accept the government first-home owner grant as a deposit for a mortgage.

this line of research in the following chapter, exploring in particular possible endogeneity in the mortgage product choice.

TABLE 5.2: Average Partial Effects: LTV sub-samples

	$Pr(VRM = 1)$			
	All	$LTV \leq 60\%$	$60\% < LTV \leq 80\%$	$LTV > 80\%$
$\widehat{RATEDIFF}$ $(R^{SFRM} - R^{VRM})$	0.546***	0.326***	0.605***	0.856***
	[0.018]	[0.027]	[0.028]	[0.049]
$\widehat{RATEDIFF}$ × Income	-0.082***	-0.053***	-0.089***	-0.123***
	[0.002]	[0.004]	[0.004]	[0.007]
$\widehat{Discount}$ $(R^{VRM} - R^{HM})$	-0.047*	0.031*	-0.071***	-0.112***
	[0.009]	[0.014]	[0.014]	[0.022]
VRM interest rate	-0.094***	-0.080***	-0.092***	-0.132***
(monthly average)	[0.003]	[0.004]	[0.004]	[0.007]
Loan > AUD $500,000	0.217***	0.197***	0.207***	0.213***
	[0.006]	[0.012]	[0.008]	[0.016]
Loan-to-value ratio (LTV)≤60%	0.012***			
	[0.002]			
Loan-to-value ratio (LTV)>80%	-0.038***			
	[0.002]			
Lowest competing SFRM rate	0.002	0.003	-0.002	0.004
	[0.004]	[0.007]	[0.007]	[0.011]
Unemployment rate	-0.059***	-0.044***	-0.075***	-0.074***
	[0.004]	[0.006]	[0.006]	[0.010]
Inflation rate	-0.011***	-0.015***	-0.010***	-0.005
	[0.002]	[0.003]	[0.003]	[0.004]
House price inflation rate	-0.002***	-0.001	-0.003**	-0.004**
	[0.001]	[0.001]	[0.001]	[0.001]
%Δ Dwelling index	0.215***	0.220***	0.221***	0.191***
	[0.007]	[0.011]	[0.011]	[0.018]
Net assistance FHBs	-0.002	0.001	0.002	-0.005**
	[0.001]	[0.003]	[0.002]	[0.002]
Age < 30 yrs. old	-0.031***	-0.052***	-0.022***	-0.015*
	[0.003]	[0.005]	[0.004]	[0.006]

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note. All values are in 2006 Q1 AUD $. Marginal effects for the probability of observing a variable rate mortgage (VRM). Estimations include the complete set of explanatory variables: mortgage costs X, market conditions W, and borrower characteristics Z. This table reports average partial effects. Coefficients which are not statistically different across sub-samples (columns (2) and (4) relative to column (3)) are reported in red color.

Table 5.2 – continued from previous page

	$Pr(VRM = 1)$			
	All	$LTV \leq 60\%$	$60\% < LTV \leq 80\%$	$LTV > 80\%$
Age 30-39 yrs. old	-0.004**	-0.014***	0.005	-0.000
	[0.002]	[0.003]	[0.003]	[0.005]
Age 50-59 yrs. old	0.007***	0.008*	0.000	-0.015
	[0.002]	[0.003]	[0.004]	[0.009]
Age $\geq$ 60 yrs. old	0.026***	0.024***	-0.002	-0.043
	[0.004]	[0.005]	[0.008]	[0.024]
Female	-0.026***	-0.026***	-0.026***	-0.030***
	[0.002]	[0.003]	[0.003]	[0.004]
Married	0.010***	0.019***	0.007*	-0.005
	[0.002]	[0.003]	[0.003]	[0.004]
Dependent $\leq$ 5 yrs. old	-0.006***	-0.004	-0.001	-0.009
	[0.002]	[0.003]	[0.003]	[0.006]
Number of dependents	-0.010***	-0.010***	-0.011***	-0.005
	[0.001]	[0.001]	[0.001]	[0.003]
First-time home buyer (FHB)	0.022***	-0.016*	0.003	0.030***
	[0.003]	[0.007]	[0.005]	[0.005]
Co-borrower	0.008***	0.021***	0.006*	-0.028***
	[0.002]	[0.003]	[0.003]	[0.005]
Mobility (p.c.)	0.031***	0.003	0.034***	0.062***
	[0.002]	[0.003]	[0.003]	[0.004]
Gross monthly income (AUD $'000)	0.019***	0.019***	0.018***	0.024***
	[0.000]	[0.001]	[0.001]	[0.001]
Living expenditure (AUD $'000)	-0.016***	-0.026***	-0.012***	0.003
	[0.002]	[0.002]	[0.002]	[0.004]
Professional	0.042***	0.036***	0.043***	0.036***
	[0.002]	[0.004]	[0.004]	[0.005]
Management	0.015***	0.018***	0.011**	0.016**
	[0.002]	[0.004]	[0.003]	[0.006]
Services	-0.036***	-0.029***	-0.040***	-0.039***

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note. All values are in 2006 Q1 AUD $. Marginal effects for the probability of observing a variable rate mortgage (VRM). Estimations include the complete set of explanatory variables: mortgage costs X, market conditions W, and borrower characteristics Z. This table reports average partial effects. Coefficients which are not statistically different across sub-samples (columns (2) and (4) relative to column (3)) are reported in red color.

Table 5.2 – continued from previous page

	$Pr(VRM = 1)$			
	All	$LTV \leq 60\%$	$60\% < LTV \leq 80\%$	$LTV > 80\%$
	[0.003]	[0.005]	[0.005]	[0.008]
Skilled-trade	-0.019***	-0.008*	-0.019***	-0.036***
	[0.002]	[0.004]	[0.004]	[0.006]
Unskilled-trade	-0.047***	-0.023***	-0.053***	-0.071***
	[0.003]	[0.005]	[0.004]	[0.007]
Agriculture	-0.062***	-0.039***	-0.089***	-0.071**
	[0.008]	[0.011]	[0.013]	[0.023]
Unemployed	0.027***	0.030***	0.006	0.011
	[0.003]	[0.004]	[0.006]	[0.014]
Small business proprietor	-0.001	0.005	-0.001	0.003
	[0.004]	[0.005]	[0.006]	[0.016]
Self-employed	0.010***	-0.005	0.021***	0.039***
	[0.003]	[0.003]	[0.004]	[0.010]
Net wealth (AUD $'0000)	0.000***	0.000***	0.000***	-0.000
	[0.000]	[0.000]	[0.000]	[0.000]
Liquid assets (AUD $'0000)	0.000***	0.000***	0.000***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
Short-term liabilities (AUD $'0000)	-0.001***	-0.001***	-0.001***	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
Time with Bank (yrs.)	0.004***	0.006***	0.002***	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
Number of credit accounts	0.016***	0.010***	0.022***	0.022***
	[0.001]	[0.002]	[0.002]	[0.003]
Number of credit facilities	0.017***	0.011***	0.014***	0.040***
	[0.001]	[0.002]	[0.002]	[0.004]
P*seudo* - R^2	0.0572	0.0453	0.0651	0.0749
N	452,163	187,760	190,233	74,170

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note. All values are in 2006 Q1 AUD $. Marginal effects for the probability of observing a variable rate mortgage (VRM). Estimations include the complete set of explanatory variables: mortgage costs X, market conditions W, and borrower characteristics Z. This table reports average partial effects. Coefficients which are not statistically different across sub-samples (columns (2) and (4) relative to column (3)) are reported in red color.

Chapter 6

Endogeneity in the Household Mortgage Choice

6.1 Introduction

This paper extends earlier literature on mortgage product choice by allowing for endogeneity of two crucial features of the loan contract – the loan-to-value ratio (LTV) and the interest rate. Although a number of previous papers accounted for selectivity bias in the mortgage product choice (see Brueckner and Follain [34], Paiella and Pozzolo [150], and Ehrmann and Ziegelmeyer [82]), endogeneity is generally not considered. We show that this extension is important for identification of the mortgage choice model and argue that it allows us to further understand the mortgage process and the effect of borrower characteristics on interest rates and LTVs. Under our specification borrower characteristics, including demographics, play a prominent role, and the endogeneity exercise shows how they affect mortgage price and the level of indebtedness.

The previous chapter established that although mortgage costs are the dominant determinant of product choice, borrower characteristics and circumstances are also significant. Risk averse borrowers facing income and wealth constraints were more likely to prefer products which reduce their initial repayments or offer repayment certainty, while those facing mobility risk and high unstable income were more likely to prefer the flexibility in a variable-rate mortgage (VRM). These results, anticipated in the theoretical literature but weakly confirmed empirically, were based on an analysis of a large loan-level dataset

of Australian mortgage applications. In particular, we were able to show that the effect of borrower characteristics was different for high LTV borrowers and low LTV borrowers when considering the LTV benchmark ratios defined by Basel capital adequacy requirements – which particularly affect lenders who retain mortgage debt on-balance-sheet.[1] We concluded that the mortgage type chosen and the LTV agreed behaved as non-rate terms in mortgage contracts to discriminate and account for credit and prepayment risk variability across borrowers.

In the earlier analyses, important explanatory variables for mortgage product choice, most notably the loan-to-valuation ratio and the contracted interest rate, were taken to be exogenous, albeit that the contracted interest rate was corrected for selection bias. Problems of sample selection arise when investigating the factors that affect mortgage interest rate determination with borrower loan-level data. The interest rate associated to the chosen mortgage is observed, but the comparative interest rates for the mortgage products not chosen are unobserved. This leads to a non-random sample that may bias the estimated results.[2]

A correction to this selection bias typically results in the prediction of unobservable mortgage costs and terms for the rejected products. This prediction is generally overlooked, although it is important as it reflects mortgage price determination.[3] In this prediction, it is possible that relevant mortgage cost variables are excluded from the specification. For example, when predicting mortgage interest rates, the size (or LTV) and term of the loan are likely to be important potential predictors, but are sometimes excluded as they fail to be exogenous explanators. Additionally, the size of the loan (or LTV) may be determined simultaneously with the value of the property under the mortgage contract. Borrowers may choose a house based on the LTV they can access, and the LTV is determined by the value of the house that borrowers want to purchase.

A specification more congruent with actual contracting arrangements would, however, recognize that the type of mortgage contract, the loan-to-value ratio, and the interest rate are all jointly determined in course of negotiations between the bank and the

[1] Mortgages with LTV of below 80 percent (and 60 percent for low-documentation contracts) attracted a 50 percent discount under Basel capital requirements in Australia before 2008.

[2] Ackerberg and Botticini [1] discuss potential important unobserved or partially observed factors in empirical work on contract choice.

[3] Ambrose et al. [9] estimate the price of conforming and non-conforming mortgages for example.

borrower. This potential simultaneity is not generally recognized in the international literature, and if it proved to be important, it would have the well-known consequence that estimates of the importance of explanatory variables are imprecise. In particular, the role of borrower characteristics, which are the focus of this thesis, may be understated.

Accordingly, this chapter analyses factors that determine the probability of choosing a VRM, taking account of both sample selection and endogeneity and using a unique loan-level database from a large Australian bank for the period between January 2003 and August 2008. We address both the selection and endogeneity problems. First, we correct for endogeneity by estimating the LTV. Second, we correct selection bias by estimating the mortgage interest rates specification using truncation methods and the predicted LTV.

We show that ignoring endogeneity between interest rates and LTV results in underestimating the role of the interest rate spread between short-term fixed-rate mortgages (SFRMs) and variable-rate mortgages (VRMs) in the mortgage choice results; supporting the evidence presented in the previous chapter. Importantly, we find that the role of borrower characteristics is consistent across methodologies and it is significant in determining mortgage choice directly and indirectly, through LTV and interest rate determination. Considering the endogeneity in the mortgage choice specification equation sheds new light on the mortgage contract process.

Our work is presented as follows; Section 6.2 presents the existing literature on mortgage product choice. Section 6.3 introduces the model specification and the methodology. Results are discussed in Section 6.4. Section 6.5 concludes.

6.2 Existing literature

Previous research on mortgage contract choice has concluded that the major determinants for the optimal mortgage choice are: the correlation between the borrower's labor income growth and the inflation rate – Baesel and Biger [19]; house price inflation – Statman [175]; and contract stipulations such as LTV, payment-to-income ratio (PTIR), and positive net wealth –Alm and Follain [7]. Campbell and Cocco [43] argue that borrower characteristics – such as income risk, risk aversion, and credit constraints – are relevant determinants in the optimal mortgage choice.

Results in empirical work are more ambiguous. Mortgage terms and costs and the prevailing economic conditions are shown to play an important role in the mortgage product choice decision, however borrower characteristics seem to be less relevant (as discussed in the previous chapter). Although some existing literature has corrected for selection bias, none has approached potential endogeneity.

Borrower characteristics are relevant because they reflect risks. Individuals face diverse risks when committing to a long-term contract such as a mortgage. Income risk reflects the borrower real income growth and volatility. Wealth risk reflects changes in the borrower's net wealth and equity.[4] The possibility that the borrower will hold the property under the mortgage contract for a short period relative to the term of the contract is defined as mobility risk.

Each of these risks has a systematic and idiosyncratic component. Market risks affect borrowers: interest rate risk is expected to be correlated with real income risk and, in some cases, wealth risk; inflation will affect both income and wealth risks; unemployment may affect income risk and mobility risk. The idiosyncratic component of borrower risk is mainly determined by the individual characteristics and circumstances of the borrower.[5]

Under a perfect market environment hedging risk is costless and borrowers should be indifferent between choosing any type of contract. If lenders price alternative contracts perfectly, with the risk premiums for interest rate fixity accurately reflecting expectations, the lender should be indifferent to the type of contract the borrower chooses. In this scenario, borrower characteristics purely reflect borrowers' preferences.

In reality markets hold asymmetric information and are subject to transaction costs. If financial institutions were able to observe borrowers' risk information and design contracts to match each borrowers' preferences, then there would be a perfect match between borrower preferences and mortgage contract – the lender would apply perfect price discrimination. Financial institutions collect an extensive amount of data on their clients, however designing contracts to suit each individual borrower is costly for the

[4]Campbell and Cocco [43] argue that adjustable-rate mortgages expose borrowers to income risk, while FRMs expose them to wealth risk.

[5]From the lender's perspective, mobility risk and positive shocks on wealth or income risk can be interpreted as prepayment risk (or liquidity risk – a mismatch between short- and long-term debt). Negative shocks on income and wealth risks are translated into default risk, and eventually recovery risk.

lender. Instead, financial institutions offer a finite set of mortgage contracts and borrowers self-select into these contracts based on their borrower characteristics.

If borrower characteristics are not relevant when choosing a mortgage type then this may suggest that: (1) the market is complete and perfectly competitive, the lender can assess borrowers' risk accurately and the borrower-contract matching is perfect; (2) lenders do not need to assess borrowers' risk (maybe they can transfer that risk to a secondary market) or they don't consider assessing their risk (maybe mortgage design is based solely on the cost of mortgage funding for the lender), and borrowers are unable or unwilling to assess their own risk; (3) the features of the contract reflect varying preferences and conditions of earlier periods (inertia), (4) the model is misspecified. Possibly one or more of these cases apply simultaneously.

Mortgage interest rates and mortgage costs (mainly the interest rate spread between the mortgage products[6]) have been shown to be strong empirical determinants of the mortgage product choice model. The variables that are used as cost comparison measures on the mortgage product choice specification are generally observable for the chosen product, but the qualities of the rejected products are unobservable. This may result in sample selection bias, and a correction may be required. In addition, it is possible that some variables are omitted or endogenously determined when predicting mortgage interest rates; for example, the size (or LTV) and term of the loan are likely to be endogenously determined with interest rates.

In this paper we argue that the LTV is endogenously determined in the mortgage interest rate determination. This argument follows from the results in the previous chapter, and recognizes mortgage product design and price.

Some existing work does not require selection bias correction in the mortgage cost explanatory variables. Dhillon et al. [73] use the market fixed interest rate and a margin on the adjustable-rate mortgage (ARM) as exogenous variables to predict the probability of taking an ARM.[7] Their results suggest that a higher fixed interest rate increases the probability of choosing an ARM, while a higher margin on the adjustable rate mortgage

[6] In particular, most studies compare the choice between an adjustable-rate mortgage (ARM) and a FRM for the U.S. mortgage market; see Dhillon et al. [73], Brueckner and Follain [34], Phillips and VanderHoff [152], Paiella and Pozzolo [150], Coulibaly and Li [54], and Ehrmann and Ziegelmeyer [82].

[7] Dhillon et al. [73] analyze 78 observations from an office of a national mortgage banker in Louisina, U.S., on loans closed over January 1983 and February 1984 with a 30-year maturity. The authors report to have results for the Probit specifications that include the initial rate on the ARM and the spread between the fixed and adjustable rate mortgages, which are not reported.

decreases the probability of taking an ARM; they argue borrower characteristics are weak determinants of the choice between an ARM and a FRM. Sa-Aadu and Sirmans [162] include the contract rate and the discount points as mortgage price terms; they match, by origination date, observed contracts costs in the sample with unobservable costs for rejected contracts.[8] They find that larger contract rates and larger discount points predict a lower probability of taking ARMs. Their results suggest that borrower characteristics influence the mortgage choice decision. Coulibaly and Li [54] use the market average spread between FRM and ARM (obtained from the Mortgage Bankers Association) and find a positive and significant coefficient for the $FRM - ARM$ interest rate spread.[9] They conclude that borrowers consider risk factors and their individual circumstances when choosing a mortgage type, strongly supporting the relevance of borrower characteristics on mortgage choice.

Other research corrects for selection bias. Brueckner and Follain [34] estimate the rate spread between mortgage contracts and correct for selection bias, but find that the correction is irrelevant.[10] The rate spread coefficient is positive and statistically significant and becomes the major determinant of the product choice; they argue borrower characteristic weakly determine mortgage choice. Phillips and VanderHoff [152] follows the procedure in Brueckner and Follain [34].[11] Paiella and Pozzolo [150] correct for selection bias,[12] however they consider sample selection into mortgage financing and the type of mortgage product chosen. They estimate a selection equation where the choice of taking a mortgage versus other financing alternative is considered, and then the probability of taking a mortgage product conditional on mortgage financing is predicted,[13] concluding that the choice of purchasing a home and financing it with a mortgage is independent of

[8] Sa-Aadu and Sirmans [162] work with a pool of 345 mortgage loans originated by a large U.S. mid-western federally chartered savings and loan association over the period 1979 to 1984.

[9] Coulibaly and Li [54] use 2,887 observations from the U.S. Survey of Consumer Finances conducted by the Federal Reserve Board for 1995, 1998, 2001 and 2004. Their work estimates a Mincer equation in oder to obtain an income volatility measure by occupation.

[10] Brueckner and Follain [34] work with a sample of 475 observations from a U.S. survey of real estate broker transactions in 1985.

[11] Phillips and VanderHoff [152] 755 observations from the U.S. Home Financing Transaction surveys conducted by the National Association of REALTORS for the years 1986, 1987, and 1988.

[12] Paiella and Pozzolo [150] work with a database of 420 observations from the Bank of Italy's Survey of Household Income and Wealth (SHIW). Also, interestingly, they find that for given common borrower characteristics the interest rate premium charged by the lender is higher for ARMs than for FRMs.

[13] In their work, the decision to buy a house and finance it with a mortgage is specified by the share of households renting a house, the average annual per-square meter rent, and the number of banks where the household holds a bank account (to proxy for information on financial instruments). They then predict the probability of taking an ARM conditional on the borrower financing the house purchase with a mortgage. The selectivity correction factor (inverse Mills ratios) appears to be insignificant, and a likelihood ratio test for independence of equations can not reject the null hypothesis.

the mortgage product choice. Paiella and Pozzolo [150] find that the higher the interest rate spread the higher the chance of choosing an ARM. They also argue that individual borrower characteristics are weak determinants in the mortgage choice decision.[14] Similarly, Ehrmann and Ziegelmeyer [82] apply a Heckman selection model, looking first at the decision to take out a mortgage, and then the type of mortgage taken, and conclude that these decisions are independent.[15] They also find a weak role for borrower characteristics in mortgage choice, but do not include the rate spread between mortgage products.[16]

A third group of papers overlooked mortgage cost variables in their analysis of the mortgage product choice, focusing mainly on other questions. Fortowsky et al. [88] estimate proportional hazard models to study the effect of mortgage choice on tenure duration, and conclude that borrower characteristics are important determinants of mortgage duration.[17] Amromin et al. [10] look at mortgage choice between ARMs, FRMs and what they define as 'complex mortgages' (CMs),[18] using the LTV and a dummy indicating when the loan is above the conforming limit as mortgage terms explanatory variables.[19] Their findings suggest borrower characteristics are important determinants of the mortgage choice. Cocco [50] studies the effect of household demographic characteristics on mortgage type, but includes only loan value or LTV to control for mortgage terms.[20] The findings suggest that some borrower characteristics are important, particularly income. Vickery [183] predicts mortgage choice also using the LTV and a conforming limit dummy as mortgage terms, and finds borrower characteristics to be irrelevant in

[14] They do not report their interest rates predictions, but declare they use as explanatory variables of the rate equations age, education, occupation, and short-term and long-term province-level interest rates on bank loans.

[15] Ehrmann and Ziegelmeyer [82] have around 8,500 observations for the Euro area provided by the Eurosystem Household Finance and Consumption Survey (HFCS) for 2010.

[16] They do include the yield spread however.

[17] Fortowsky et al. [88] obtained over 600,000 observations combining records of properties with repeat sales from a U.S. property transaction database, which covers all transactions from two GSEs and third party vendors, with loan-level information at origination date supplied by the financial institutions for the period 1998-2007.

[18] Amromin et al. [10] defined as 'complex mortgages' those mortgages which feature zero or negative amortization, short interest rate reset periods, and very low introductory teaser interest rates.

[19] Amromin et al. [10] also combine a U.S. proprietary mortgage-level dataset from Lender Processing Services Applied Analytics with household income data collected by the Home Mortgage Disclosure Act, and obtain over 10,000,000 observations between 2003 and 2009. They also calculate proportional hazard models for mortgage delinquency by mortgage product.

[20] Cocco [50] works with 3,608 observations from the British Household Panel Survey for the period 1991-2008.

the mortgage choice determination.[21] But in addition, Vickery [183] predicts bank interest rates and finds that mortgage interest rates are determined by LTV and the loan size.

A separate branch of the research concentrates directly on predicting the price of mortgages, without focusing on the identification of the mortgage product choice. Rosenthal and Zorn [159] study the effect of mobility on the pricing of fixed- and adjustable-rate mortgages.[22] They find that average monthly interest rates (FRM or ARM) are determined by the 7-year Treasury bond rate and by the average length of time that FRM borrowers stay in their homes in a particular region, after controlling by regional effects. Ambrose et al. [9] looks at the rate spread between conforming and non-conforming loans and addresses problems of endogeneity and sample selection bias.[23] They show that the spread between conforming and non-conforming mortgage interest rates depends on the loan amount, the LTV, credit score, and interest rate volatility.[24]

The aim in this paper is to improve the specification of the mortgage choice model by correcting for endogeneity in the mortgage cost variables (interest rates and LTV), and also by correcting for selection bias using truncation methods. In addition, the endogeneity correction will reveal further information on the role of borrower characteristics on interest rate and LTV determination. This paper uses the same dataset as described in the previous chapter. The next sections present the methodology and results.

[21] Vickery [183] combines U.S. survey data from Monthly Interest Rate Survey (MIRS), Survey of Consumer Finances (SCF) and the Residential Finance survey (RFS), obtaining over 200,000 observations between 1992 and 2005.

[22] Rosenthal and Zorn [159] use a panel dataset from the U.S. Federal Home Loan Bank Board Survey of Mortgage Lending with 427 observations from January 1984 through April 1988. They also estimate a simultaneous system in which the $FRM - ARM$ rate spread might influence the FRM rate and vice versa using a nonlinear two-stage least squares procedure (footnote 30 in page 247). They include the spread between the 10-year and 5-year Treasury bonds, however it shows weak predictive power.

[23] Ambrose et al. [9] look at micro-level data on 26,179 FRMs between January 1995 to December 1997 originated by a U.S. lender and mortgage brokers. See also Hendershott and Shilling [110] and Ambrose et al. [8]. For a summary table of research on the conforming/non-conforming rate differential see McKenzie [142].

[24] They also control for the slope of the yield curve, regional variability, and the legal environment.

6.3 Setup

6.3.1 Empirical model specification

We consider the following binary model of mortgage product choice, where the household chooses between a variable-rate mortgage (VRM) and other mortgage products. Let y_i denote the contract chosen by household i, $i = 1, \ldots n$. We assume that $y_i = 1$ if i chooses a VRM and $y_i = 0$ otherwise. We are interested in estimating the conditional probability of choosing a VRM, $\mathbb{P}(y_i = 1 \mid I_i)$, as well as the determinants of this probability; where I_i is the information set at application time that contains market variables, such as the interest rates offered in each type of mortgage contract, as well as borrower characteristics. Specifically, we consider the Probit model of the form,

$$\mathbb{P}(y_i = 1 \mid I_i) = \mathbf{\Phi}(\beta_0 + \beta_1 RateSpread_i + \beta_2 Discount_i + X_i'\delta) \tag{6.1}$$

where $(\beta_0, \beta_1', \beta_2', \delta')'$ is an unknown coefficient vector; *RateSpread* is the rate differential between the interest rate offered in a SFRM and the one offered in a VRM; *Discount* is the rate differential between the interest rate offered in a VRM and that one offered in a 'honeymoon' mortgage – the discount offered in a discounted variable-rate mortgage; X includes household and market characteristics relevant in mortgage product choice; and $\mathbf{\Phi}(.)$ is the cumulative density function (*cdf*) of a standard normal distributed random variable.

In practice, borrowers compare the rates offered for each type of contract. As discussed in the previous section, the interest rate differentials, *RateSpread* and *Discount*, are important determinants of mortgage product choice. It is anticipated the rate differential between SFRM and VRM, *RateSpread*, should have a positive impact on the probability of choosing a VRM. A larger rate spread between SFRM and VRM increases the probability of a borrower choosing a VRM. In principle, lenders should be indifferent to the type of mortgage contract they offer to borrowers when the rate spread between SFRM and VRM increases. This latter scenario corresponds to situations where lenders price contracts perfectly and the risk premiums for interest rate fixity reflect expectations accurately.

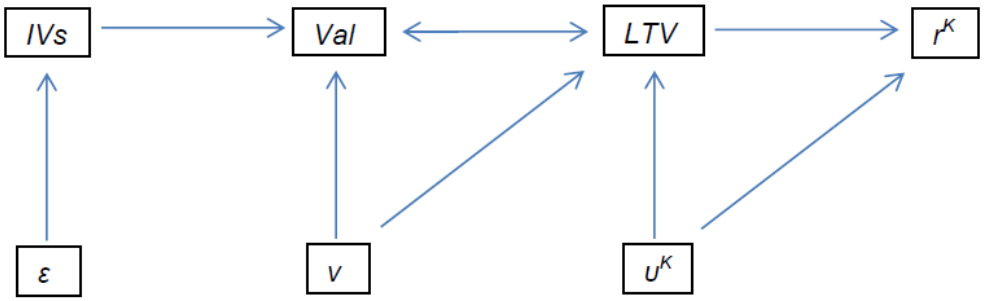
Following previous work, we predict the mortgage interest rates for each contract and the rate differential is subsequently built from:

$$r_i^k = \eta^k LTV_i + V_i'\gamma^k + X_i'\delta^k + u_i^k,\ u_i^k \sim N(0, \sigma_k^2),\ i = 1, \ldots, n_k, \tag{6.2}$$

where r_i^k is the interest rate for individual i who chooses a contract k, $k = \{VRM, HM, SFRM\}$, n_k are the number of individuals who choose each contract ($n_{VRM} + n_{HM} + n_{SFRM} = n$), LTV is the loan-to-value ratio, V are other factors that determine the interest rates on SFRM, VRM and HM products respectively, η^k, γ^k and δ^k are unknown coefficient vectors, and u^k are unobserved error terms.

Two major problems arise with model (6.2). First, the model is truncated because the interest rates for the contract chosen are observed only for the subsample in each case, n_k, which suggests sub-samples are non-random.[25] Second, model (6.2) also suffers from an endogeneity problem; the LTV and the interest rates, r^k, may be jointly determined. In addition, LTV is jointly determined with the value of the purchased property under mortgage, which is not part of the interest rate equations; see Ambrose et al. [9]; see Figure 6.1.

FIGURE 6.1: Endogeneity Diagram.



[25] The sample selection bias arises because individuals may have chosen a SFRM or a HM because the interest rates for this contracts, r^f (SFRM) or r^h (HM), were more favorable. This may be the case if market expectations dictate particularly favorable short-term variable rates, or lenders decided to subsidize some contracts with others, or lenders' funding strategies favor one contract over another. Also, it is possible that the lender may only offer one type of contract to certain borrowers (e.g. borrowers with liquidity constraints, bad credit history, or fist-time home buyers), or on the other hand, that borrowers that choose a certain type of contract have a better capacity to negotiate their rates.

To deal with this, we consider the following specification:

$$LTV_i = \alpha_0 + \alpha_1 \log(Val_i) + V_i'\alpha_2 + X_i'\alpha_3 + \nu_i, \tag{6.3}$$

$$\log(Val_i) = \pi_0 + \pi_1 LTV_i + V_i'\pi_2 + X_i'\pi_3 + Z_i'\pi_4 + \epsilon_i, \tag{6.4}$$

where LTV_i is the loan-to-value ratio; Val_i is the value of the property under the mortgage contract; $(\alpha_0, \alpha_1, \alpha_2', \alpha_3', \pi_0, \pi_1, \pi_2', \pi_3', \pi_4',)$ is a vector of unknown coefficients; Z_i is a vector of instruments (IVs);[26] V_i is a vector of explanators in equation (6.2); X_i is a vector of the control variables in equation (6.1); and ν_i and ϵ_i are unobserved errors with zero mean. The reverse causality between the loan-to-value (LTV) and the value of the property (Val) is justified by the fact that borrowers decide on the property they purchase on the basis of accessible LTV, and the LTV itself is determined by the value of the property

In the next section we describe the estimation of the models, however in the following subsections we first present our methodology and the IVs selection process.

6.3.2 Methodology

To estimate models (6.1)-(6.3), we proceed as follows:

1. First, we estimate (6.3), and recover the fitted values $\widehat{LTV}$ of LTV;[27]
2. Second, we replace LTV by $\widehat{LTV}$ in equation (6.2), and estimate the model using truncation methods. We recover the fitted values for the mortgage interest rates, $\widehat{r}^k$, and compute:

$$\begin{aligned} \widehat{RateSpread}_i = &\quad (\hat{\eta}^{SFRM} - \hat{\eta}^{VRM})\widehat{LTV}_i + V_i'(\hat{\gamma}^{SFRM} - \hat{\gamma}^{VRM}) + X_i'(\hat{\delta}^{SFRM} - \hat{\delta}^{VRM}) \\ \widehat{Discount}_i = &\quad (\hat{\eta}^{VRM} - \hat{\eta}^{HM})\widehat{LTV}_i + V_i'(\hat{\gamma}^{VRM} - \hat{\gamma}^{HM}) + X_i'(\hat{\delta}^{VRM} - \hat{\delta}^{HM}) \end{aligned}$$

3. Finally, we replace $RateSpread$ by $\widehat{RateSpread}$ in (6.1) and estimate the Probit.

Sample selection bias arises because although $\mathbb{E}(u_i^{VRM}) = 0$ (or $\mathbb{E}(u_i^{SFRM}) = 0$, or $\mathbb{E}(u_i^{HM}) = 0$) in equation (6.2), it is likely that $\mathbb{E}(u_i^{VRM} \mid y_i = 1) \neq 0$ (respectively

[26] See section 6.3.3 for an explanation of IVs selection.
[27] We report evidence of endogeneity and the procedure to select good IVs in 6.3.3.

$\mathbb{E}(u_i^{SFRM} \mid y_i = 0) \neq 0$ and $\mathbb{E}(u_i^{HM} \mid y_i = 0) \neq 0$). Endogeneity arises between the LTV and that interest rates which maybe jointly determined and, moreover, the LTV is simultaneously determined with the value of the property purchased with mortgage; $Corr(\nu_i, Val_i) \neq 0$ in equation (6.3), which suggests that $Corr(u^k, LTV_i) \neq 0$ in equation (6.2).

To the best of our knowledge, none of the previous work on mortgage choice addresses possible endogeneity. Results of our estimations are shown in Tables 6.2 and 6.3, and are discussed in the next section. Before proceeding, we discuss instrument selection.

6.3.3 Instrument selection

We consider several instrumental variables to explain the value of a property under a mortgage. The list of potential candidate IVs consists of: (1) the percentage change in the dwelling index calculated by the Melbourne Institute reflecting house price expectations (obtained from a survey asking whether it is a good time to buy a house); (2) the time in years the applicant has spent at the current and previous addresses; (3) the time in years the applicant spent at the current and previous employments; (4) the age, and a quadratic term in age; (5) female applicants; (6) the marital status of the applicant; (7) the number of dependents; (8) the properties to be built; (9) new dwelling properties; (10) the postcode for the property under the mortgage; (11) the net wealth of the borrower at time of application; (12) the level of liquid assets at time of application; and (13) the unskilled trade occupational category for the applicant.

Potential good IVs need to explain the value of the property under the mortgage contract, but will not directly affect the LTV. The list of potential IVs discussed above affect the value of the property. At times of high house price expectations – as reflected by an increase in the dwelling index – properties become more expensive. Otherwise similar borrowers who have spent more time at their current and previous addresses – and are therefore long-term residents and less mobile – are more likely to invest more in their properties seeking higher quality associated with higher house prices. In addition, otherwise similar borrowers who have spent more time at their current and previous employments are more likely to be able to afford a property with a higher value, as they show stable employment. While young and older applicants may prefer small low-maintenance houses, middle aged applicants, married and females with children may

look for larger and more expensive homes. New or to be built dwellings have higher value than similar older ones, and house prices vary across neighborhoods and locations (captured by postcodes). Wealthier borrowers with greater liquid assets afford larger and more expensive properties. Mortgage applicants who are unskilled trade workers in the construction industry may buy low price houses and add value to them (through maintenance or extensions and renovations).

Some of these potential instrumental variables may affect the LTV through different channels rather than through the value of the property. For example, the level of wealth and liquid assets will determine the deposit for a mortgage and the LTV directly. The age, marital status and number of dependents are good proxies for risk aversion, aiding the bank in assessing borrowers' credit or default risk – an important consideration for LTV determination.

We used the backward sequential procedure based on the Sargan [165] test to select the IVs that satisfy the exclusion restrictions.[28]

1. First, when using all instruments, the Sargan-Hansen statistic is very large (over 9,000) with a p-value of 0.0000, thus indicating strong evidence of instrument invalidity – see column (1) in Table 6.1.

2. Second, we eliminate one by one the instrumental variables with high impact on the Sargan-Hansen statistic so that the Sargan-Hansen statistic becomes smaller than the previous step. The variables removed as instrumental variables are added as control variables in the next step.

3. Third, this procedure is repeated and we retain the set of IVs that pass Sargan [165] test, these are: new house, dwelling to be built, and married. With these three IVs the Sargan-Hansen statistic is 1.58 with a p-value of 0.4541 – see column (4) in Table 6.1.

[28] Note that we could use the moment selection procedure in Andrews [12], but for simplicity, we only consider the sequential backward selection only.

6.4 Model estimation

We proceed to apply the steps explained in the previous section, and discuss the results for endogeneity and sample selection correction for the mortgage contract choice determination – equation (6.1). We then concentrate on the interpretation and findings of the endogeneity correction by explaining the LTV and mortgage interest rates predictions – equations (6.2) and (6.3).

6.4.1 Mortgage choice

Table 6.2 presents the predicted probabilities of taking a VRM, applying equation (6.1) and using the constructed rate spreads $\widehat{RateSpread}$ and $\widehat{Discount}$.[29] The results are consistent with the theoretical predictions for the effect of borrower characteristics on mortgage product choice. In addition, the results show that the effect of the rate spread, $\widehat{RateSpread}$, on the probability of taking a mortgage product is generally underestimated when ignoring potential endogeneity problems.

The first column in Table 6.2 describes the rich set of explanatory variables;[30] the second column shows results for the mortgage choice specification with no correction for selection bias or endogeneity; the third and fourth columns show the estimated coefficients when correcting selection bias through 2SLS with inverse Mills ratios – as in Brueckner and Follain [34] and Lee [136] – and truncation methods respectively, with no endogeneity correction; the fifth and sixth columns present the results for selection bias and endogeneity correction. The sixth column shows the results following the methodology in subsection 6.3.2; these are our preferred results and most of the following comments are based on them.

When comparing across models, the second and fourth columns show that the coefficients for the estimated models without selection bias correction and with selection bias correction using truncation methods are identical when no endogeneity problems are considered, suggesting that the potential non-randomness of the sample is not an issue in the estimation process. The third column, where the selection bias is corrected using

[29] The estimation proceeds as a pooled Probit regression, taking into account the time of application, t, as a component of the explanatory variable.

[30] The explanatory variables used in the previous chapter and this chapter are slightly different; in addition, all monetary values in this chapter are presented in a logarithmic form.

2SLS with Inverse Mills ratios, shows qualitatively identical results. However, the last two columns, which correct for endogeneity, present some differences when compared to the previous columns. The main difference across model predictions results when comparing the rate spread, $\widehat{RateSpread}$. The estimates with endogeneity correction predict an effect 2 times larger for $\widehat{RateSpread}$ than the estimates without endogeneity correction.[31] Meanwhile, the coefficient for $\widehat{Discount}$ is consistent across models. The endogeneity and selection bias corrected model – in column 6 of Table 6.2 – predicts that a 100 basis points increase in the spread between SFRM and VRM interest rates, $\widehat{RateSpread}$, results in a 28 percent increase in the probability of taking a VRM. Similarly, a 100 percentage point increase in the discount on HMs, $\widehat{Discount}$, decreases the probability of taking a VRM by 20.5 percent.

This strong result suggests that the effect of the difference between the SFRM and VRM interest rates at the time of choosing a mortgage product is understated when the endogeneity effect of LTV on mortgage interest rates is not considered. That is, if we acknowledge that interest rates and LTV are jointly determined, then we find that borrowers are more sensitive to the interest rate comparison across VRMs and SFRMs at the time of choosing a mortgage. This supports the evidence presented in the previous chapter. The implication of this result is that although borrowers may seem short-sighted by selecting a mortgage contract based on the lowest initial interest rate, the loan amount they can access is also considered in that decision.

Moreover, when the endogeneity between LTV and interest rates is ignored, the fact that the bank is offering the lowest fixed interest rate (*Lowest competing SFRM rate*) in the market has no effect on the mortgage product choice. However, we observe that borrowers are less likely to take a VRM if the bank is offering the lowest SFRM interest rate across all authorized deposit taking institutions, after controlling for endogeneity in the interest rate determination.

Exogenous market conditions also affect the mortgage choice, and the effects are consistent with those found in the previous chapter. The strongest effect is given by the housing market sentiment revealed by a change in the dwelling index, suggesting borrowers expecting higher equity on the value of the property secured under the mortgage

[31] Similar differences are observed for market indicators, such as the unemployment rate and house price inflation rate.

contract are more likely to select a flexible contract such as a VRM with low early prepayment costs.

Importantly, the estimates for the effects of borrower characteristics on mortgage product choice are consistent across all methodologies, reinforcing the relevance of borrower characteristics in the mortgage market.

We argue that borrower characteristics affect mortgage choice both directly and indirectly – via interest rate and LTV determination. Some borrower characteristics are relevant factors in the determination of LTV, property value, and interest rates, as reported in the following subsection, but lose significance in the mortgage product choice determination. Such variables are, for example, the rent income received and variables related to employment (the time at previous and current employment, and occupational categories like management, skilled-trade, agriculture, retired and small business proprietor). The direct effect of borrower characteristics on the probability of taking a VRM is consistent with results in the previous chapter and with the existing literature.

Borrowers who are more likely to take a VRM, relative to the benchmark borrower, are professional applicants over 50 years old, with high levels of income, wealth and liquid assets, who are mobile. Borrowers who select away from VRM in favor of mortgage contracts with some certainty feature but higher early termination costs, such as SFRM and HMs, are applicants under 40 years old, females, and applicants with dependents with high monthly expenditure, in an unskilled-trade occupation.

In the next sub-section we explore the indirect effects of borrower characteristics on LTV and interest rate determination.

6.4.2 Mortgage price and LTV

This section interprets the results for LTV and interest rate determination, and presents a context for the effect of borrower characteristics on mortgage choice. This additional step provides further understanding of mortgage choice regarding product design and price.

Table 6.3 presents the estimation results for LTV and interest rate determination – equations (6.2) and (6.3). The first column describes the explanatory variables and the

second column shows the estimation of the LTV – equation (6.3). Following Ambrose et al. [9] and Ling and McGill [139], we argue that the LTV and the value of the property purchased with a mortgage are simultaneously determined; while the lender determines the LTV based on the value of the property under the mortgage contract, the borrower purchases a property based on the amount financed by the bank, given by the LTV. For this reason, we use IV methods to predict the LTV.

The results show that the value of the property purchased is not significant in determining the initial LTV.[32] In the process of selecting the IVs, when we used only 3 IVs (new house, dwelling to be built, and married), the exclusion restriction in the Sargan [165] test was rejected supporting the validity of the IVs; see column (4) in Table 6.1. In addition, for these selected IVs the Stock-Yogo test rejects weak instruments, suggesting that the instruments proposed are strong; see Stock et al. [177] and Stock and Yogo [178]. This is supported by Shea [170] partial R^2. The standard t-test based on the 2SLS estimator shows that the coefficient on $\log(Val)$ is not statistically significant at the 5 percent nominal level. This result is confirmed by weak instrument robust procedures. Indeed, both Anderson et al. [11] AR-test and Moreira [145] CLR-test found no evidence against the null hypothesis that the coefficient on $\log(Val)$ is zero. (Is important to note that for all instruments, and almost all combination of instruments, the null hypothesis of the specified endogenous regressor being exogenous is rejected.)

This strong result suggests that the bank only assesses LTV based on variables that proxy for default risk of the borrower, and it uses the postcode of the property, house price inflation and expectations to asses the value of the property. However, it does not consider quality of the house – measured by whether the house is new or the dwelling is to be built – or expected family size.[33] The value of the property $\log(Val)$ has no impact in explaining the LTV offered to the borrower after exogenous variables – such as property postcode, percentage change in the dwelling index, net wealth, unskilled trade occupation, number of dependents, and age – are treated as control variables and not IVs in the endogeneity correction.

[32] Ambrose et al. [9] find a negative statistically significant relationship between house value and LTV.

[33] The bank does not collect information on the size in square meters of the property, or the number of rooms, construction material and other house features. Although there are some fields in the database for number of bedrooms and external construction material, these fields are largely incomplete, supporting the finding that the bank does not assess individual house quality.

This finding connects to the literature on the reverse causality between house prices and credit constraints; see Duca et al. [76], Geanakoplos [96] and Lamont and Stein [130]. Our results show that if borrowers believe the real estate market is improving – as reflected by an increase in the dwelling index – they will take mortgages with LTVs 2.3 percent higher than otherwise.

Macroeconomic indicators also affect the initial LTV. A 100 basis point increase in the interbank interest rate decreases the LTV by 11.9 percent, reflecting a contraction in the supply of credit as a result of a rise in the cost of credit, ceteris paribus. This result has relevant implications for monetary and regulatory policy, particularly for lenders who hold most of their mortgage debt on balance sheet and source most of their funding from wholesale debt – as is the case in the Australian mortgage market. In a similar fashion, higher interest rate expectations, as revealed by the slope of the yield curve, decrease the initial LTV.

Some other interesting results related to mortgage design are revealed in the second column of Table 6.3. For example, when the bank is offering the lowest fixed interest rates (*Lowest competing SFRM rate*) in the market, it is also offering lower LTVs than otherwise. This may be a result of a marketing strategy to attract new clients. In addition, we observe that higher bank fees are associated with mortgages with higher LTVs, and we confirm that short-term mortgages – for example a mortgage for 5 or 10 years rather than 25 years – have higher associated initial LTVs.

Borrower characteristics have a significant role in the LTV determination. We discuss them distinguishing income, mobility and wealth, credit risk and risk aversion. The benchmark mean applicant is male, a repeat-buyer in his forties, single, with no dependents, and employed, with a gross monthly income of AUD $6,839; and takes a loan of AUD $205,943 with an LTV of 63.35 percent.

Low income risk borrowers access high LTV mortgages; see also Ling and McGill [139], Cunha et al. [56] and Ambrose et al. [9]. We observe that those borrowers with higher than average income levels, who receive income from rent, who are professionals or in a management position, have spent longer years at their current and previous employments, and have a co-applicant (that can supplement income towards repayments) access higher LTVs than the benchmark applicant. A 1 percent increase in the borrower's monthly gross income ($74.32) increases the LTV by 10.5 percent. These applicants are

existing customers of the bank and hold more credit accounts. Meanwhile, constrained borrowers with lower than average income levels and higher than average monthly expenditure levels, who receive income from government benefits hold mortgages with considerable lower LTVs than the benchmark borrower.

Mobile borrowers also obtain higher LTVs. Borrowers who have spent longer time at their current and previous addresses receive lower LTVs, while those applicants moving away from their current postcode (and who are presumably more mobile) take mortgages with slightly higher LTVs; Ling and McGill [139] also finds similar evidence between LTVs and the probability of moving. This result may reflect both a consumption and investment motive behind the purchase of a property, and adds to the hypothesis that borrowers with little home equity, who tend to be highly indebted, find it more difficult to move as the sale of their house may be insufficient to cover the repayment and the new housing costs.

As expected, borrowers with larger wealth take lower LTV mortgages, as borrowers are able to contribute higher deposits towards the loan; see also Cunha et al. [56]. A 1 percent increase in the level of net wealth at the time of application decreases the LTV by 10.8 percent.

Borrowers with high credit risk – such as those with a bankruptcy or default flag in their application – get mortgages with LTVs 5 percent lower than the benchmark applicant. However, we find that ten more points in the borrower's external credit score decreases the LTV by 3.8 percent; Ambrose et al. [9] also finds a negative relationship between credit scores and LTVs.

Results for the effect of risk aversion on LTVs are ambiguous. Females, older borrowers, and borrowers with dependents – who tend to be more risk averse or financially inexperienced – take mortgages with lower LTVs relative to the benchmark borrower.[34] However, small business proprietors and self-employed borrowers – who tend to be less risk averse and more financially savvy – also take lower LTVs relative to the benchmark borrower. While the first group of borrowers may be self-selecting into lower LTV mortgages, the second group may be only offered low LTV mortgages. Some self-employed or

[34] Cunha et al. [56] finds similar results for age, while Ling and McGill [139] finds that higher levels of mortgage debt are positively related to age and number of children.

small business proprietor borrowers may find it difficult to provide financial documentation to the lender, and may take low-documentation loans. As discussed in the previous chapter, authorized deposit-taking institutions had incentives to provide low LTV loans to these borrowers as they accessed a 50 percent discount on capital requirements for low-documentation mortgages with LTVs lower or equal to 60 percent before 2008. Our data does not allow us to identify low-documentation borrowers.

While we find that low income risk, mobile borrowers take high LTV mortgages, there are potentially two groups of borrowers holding low LTV mortgages. The first group are financially constrained and risk averse borrowers who hold mortgages with considerable lower LTVs than the benchmark borrower. The second group are borrowers with larger wealth, lower risk aversion and more financially savvy, and those with high credit risk, who also hold lower LTV mortgages relative to the benchmark borrower. This suggests that while some borrowers may prefer lower debt levels, others may face credit constraints.

In contrast to some of the literature, we find interest rates to be negatively related to LTVs; see Ambrose et al. [9] and Vickery [183]. Mortgages with initial LTVs 10 percent higher than the average initial LTV (63 percent) pay 2.3 and 1 percent lower interest rates for VRMs and SFRMs respectively, but 0.6 percent higher interest rates for HMs. This result may be due to the fact that some borrowers with low LTVs are non-conforming or low-documentation borrowers with higher associated interest rates. This result in presented in columns 3 - 5 in Table 6.3 – the estimation results for equation (6.2).[35] Column 3 predicts interest rates for VRMs, column 4 for SFRMs, and column 5 for HMs. Most estimated coefficients have equal signs for VRMs and SFRMs but the opposite sign for HMs, suggesting this later mortgage product is targeted to a particular group of borrowers. This is consistent with the evidence presented in Chapter 4.

The strongest determinants for both mortgage LTVs and interest rates are borrower income, wealth and the interbank rate reported by the RBA. When the interbank rate increases 1 percent, the VRM interest rate is 1.7 percent lower than during 'average' times; the HM interest rate is 1.8 percent higher respectively. This result is supported by the coefficients for the slope of the yield curve. The market average interest rate for standard variable rate loans has been on average 180 basis points above the interbank

[35] We present interest rates estimated with a truncation model; estimations with a 2SLS with bias selection correction using inverse Mills ratios give almost identical results.

rate during the sample period.[36] Our results reflect contemporaneous effects and may lack an adjustment to the new interest rates.[37]

In addition, borrowers with average monthly income 1 percent higher than the average borrower – for a common average LTV – face 2.3 (1.0) percent higher interest rates associated to VRMs (SFRMs); however, those same borrowers get 0.5 percent lower interest rates for HMs. Borrowers with a 1 percent larger level of wealth at the time of application than the average borrower receive lower interest rates for VRMs and SFRMs (2.5 and 1.1 percent lower respectively), but higher rates for HMs (0.7 percent higher).

We find that borrower characteristics affect the loan-level interest rate determination revealing risk assessment, market power and negotiation power from the mortgage parties.

On the one hand, females, older (over 50 years old) and retired applicants, and those with dependents take VRM or SFRM mortgages with lower interest rates than the benchmark VRM and SFRM borrower. Applicants with higher than average monthly expenditure, and higher than average levels of net wealth at application also pay lower interest rates for VRMs and SFRMs than the benchmark VRM and SFRM borrower. In addition, borrowers who are unemployed, self-employed, small business proprietors, or in skilled- and unskilled-trade occupations have lower VRM and SFRM associated interest rates than the benchmark VRM and SFRM borrower. Retired, unemployed and self-employed applicants pay rates up to 1.7 percent lower than the benchmark applicant. Borrowers with these characteristics tend to take smaller loan amounts with lower interest rates – after controlling for LTV.[38]

On the other hand, young borrowers (under 40 years old) and first-time home buyers pay lower interest rates for HMs than the benchmark HM borrower; presumably a strategy to attract these new customers. First-time home buyers (FHBs) pay higher interest rates for VRMs (0.7 percent) and for SFRMs (0.3 percent) relative to the benchmark borrowers taking these mortgages, but receive larger discounts on HMs (0.2 percent) than the benchmark HM borrower. However, borrowers who receive first-time home buyer's net assistance from the Government access lower interest rates for VRMs and

[36] See RBA, F1 Interest Rates and Yield, and F5 Indicator Lending Rates.

[37] Future work will address this issue by using lagged values for the interbank rate.

[38] Adding the mortgage loan size as an explanatory variable in our predictions would generate multicollinearity with the LTV and the value of the securitized property, however we check our results by predicting loan size rather than LTV.

SFRMs, but higher rates for HMs. In addition, HMs borrowers with higher than average income, those applying with a co-borrower, and those in professional, management and agricultural occupations also pay lower interest rates than the benchmark borrower taking HMs. This last result may reflect risk assessment, and borrowers' negotiation power. A similar result is observed for HM borrowers who are more mobile – proxied by moving postcodes and lower time at their current and previous addresses[39] – and with more stable employment – proxied by the time spent at current and previous employments. Those borrowers who are existing customers of the bank and who have more credit accounts and credit facilities also receive lower HMs interest rates than the benchmark HM borrower.

Surprisingly, our results show that borrowers taking VRMs and SFRMs face lower interest rates when their application has a bankruptcy or default flag, but this result is the opposite for borrowers taking HMs. A 10 point increase in the credit score reduces the interest rate in a VRM (SFRM) by 0.01 (0.03) percent, but it increases the interest rate in a HM by 0.2 percent. These results are quite puzzling and opposite to a priori expectations.

Overall, we find that the value of the property under the mortgage contract does not determine the LTV after controlling for market house price inflation and expectations, postcode and borrower characteristics. The LTV is negative and statistically significantly related with the interest rates for VRMs and SFRM, but positively and statistically significantly related with HM interest rates. Finally, borrower characteristics play a role in determining both LTV and interest rates; in particular borrowers' income, wealth level and the interbank rate reported by the RBA are the strongest determinants of both mortgage LTVs and interest rates.

6.5 Conclusion

In this chapter we revisit the factors that determine the probability of choosing a variable-rate mortgage (VRM) with the aim of identifying the mortgage choice equation by considering the problem of endogeneity in loan-to-value ratio (LTV) and interest rate

[39]Rosenthal and Zorn [159] find that average monthly interest rates are determined by the 7-year Treasury bond rate, and most importantly, by the average length of time that FRM borrowers stay in their homes in a particular region (after controlling for regional effects) – proxied by the percentage of all homeowners that moved into their homes within the past 5 years for that region.

determination. Although a number of previous papers accounted for selectivity bias in the mortgage product choice, endogeneity is generally not considered.

Here, we address both the selection and endogeneity problems. First, we correct for endogeneity by estimating the LTV. Second, we correct selection bias by estimating the mortgage interest rates specification using truncation methods and the predicted LTV. Finally, we predict the probability of taking a variable-rate mortgage. We show that the endogeneity correction alters the effect of the interest rate comparison between SFRMs and VRMs, but does not affect the effect of borrower characteristics in the mortgage product choice. In addition, the endogeneity exercise reveals borrower patterns in the LTV and interest rate determination. We believe this last step enriches the existing literature on mortgage choice.

We use an extensive loan-level and individual-level bank-originated dataset on mortgage applications for Australia for the period between January 2003 and August 2008. Ignoring endogeneity between interest rates and LTV results in underestimating role of the interest rate spread between short-term fixed-rate mortgages (SFRMs) and variable-rate mortgages (VRMs) in the mortgage choice results; supporting the evidence presented in the previous chapter. We argue that although borrowers may seem short-sighted selecting the mortgage contract with the lowest initial interest rate, the loan amount they can access is also being considered in that decision.

Importantly, we find that the role of borrower characteristics is consistent across methodologies and it is significant in determining mortgage choice directly and indirectly, through LTV and interest rate determination. This approach improves our understanding of the risk assessment and risk sharing in the mortgage market.

The direct effect of borrower characteristics on the probability of taking a VRM is in line with results in the previous chapter and in the existing literature. We find that borrowers who are more likely to take a VRM, relative to the benchmark borrower, are professional applicants over 50 years old, with high levels of wealth and liquid assets. We confirm that mobile borrowers are also more likely to take a VRM. Borrowers who select away from VRM in favor of mortgage contracts with some certainty feature but higher early termination costs, such as SFRM and HMs, are applicants under 40 years old, females, and applicants with dependents. Borrowers with higher gross monthly income and monthly expenditure are also less likely to select a VRM.

The indirect effect of borrower characteristics on mortgage choice can be seen by interpreting the results for LTV and interest rate determination.

We show that low income risk, mobile borrowers take high LTV mortgages. However, there are potentially two groups of borrowers holding low LTV mortgages. On the one hand, financially constrained, risk averse borrowers, and those with high credit risk hold mortgages with considerable lower LTVs than the benchmark borrower. On the other hand, larger wealth, less risk averse and more financially savvy borrowers also hold lower LTV mortgages relative to the benchmark borrower.

We find that borrower characteristics affect the loan-level interest rate determination revealing risk assessment, market power and negotiation power from the mortgage parties. Risk averse borrowers and those with unstable income take VRM or SFRM mortgages with lower interest rates than the benchmark VRM and SFRM borrower. In addition, we observe 'honeymoon' mortgages (HMs) are targeted to a particular group of borrowers. In particular, young borrowers and first-time home buyers pay lower interest rates for HMs; presumably a strategy to attract these new customers. HMs borrowers with higher than average income, applying with a co-borrower, and in professional, management and agricultural occupations also pay lower interest rates than the benchmark borrower taking HMs. This latter result may reflect risk assessment, and borrowers' negotiation power. A similar result is observed for HM borrowers who are more mobile and with more stable employment.

Furthermore, we observe some other important micro and macro effects reflected in our results for LTVs and interest rate determination.

We find that the value of the property purchased is not significant in determining the initial LTV in the Australian case. This strong result suggests that the bank does not consider the value of the specific property secured under the mortgage at the time of application, but rather considers the postcode of the property, house price inflation and expectations, and proxies for default risk of the borrower. In particular, it does not consider quality of the house – measured by whether the house is new or the dwelling is to be built – or expected family size. This finding builds on the literature on the cycle between house price and credit growth. In particular, our results show that if borrowers (and lenders) believe the real estate market is improving – as reflected by an

increase in the dwelling index – they will take (and offer) mortgages with larger LTVs than otherwise.

In contrast to some of the literature, we find interest rates to be negatively related to LTVs. We argue this result may be due to the fact that some borrowers with low LTVs are non-conforming or low-documentation borrowers with higher associated interest rates.

The effects of macroeconomic indicators on the initial LTV have relevant policy and regulatory implications for the mortgage market. In the Australian case – where major banks finance their mortgage debt mainly through domestic deposits and wholesale debt and the regulatory authority gives incentives of capital requirement discounts for low LTVs – a hundred percentage points increase in the interbank interest rate decreases the initial LTV by more than 10 percent, a significant contraction in the supply of credit as a result of a rise in its cost. We show that higher interest rate expectations also decrease the initial LTV. In addition, during periods of relatively high unemployment rates we observe initial lower LTVs. These considerations are important to maintain sustainable individual housing debt.

This chapter has presented important findings related to mortgage choice, mortgage price and loan-to-value ratio determination. We intend to extend this work by observing the effect of the loan size, rather than the LTV, on the interest rate prediction.

TABLE 6.1: IV Diagnostic Tests

Tests	(1)	(2)	(3)	(4)	(5)
Weak identification					
Cragg-Donald Wald (F)	2,873.5***	1,901.0***	573.9***	473.7***	49.7***
Stock-Yogo					
5%	21.18	18.37	16.85	13.91	19.93
10%	11.52	10.83	10.27	9.08	11.59
20%	6.45	6.77	6.71	6.46	8.75
Anderson CCC (χ^2)	30,109.5***	8,808.1***	2,253.2***	1,404.9***	99.3***
Cragg-Donald Wald (χ^2)	40,244.8***	9,508.6***	2,296.4***	1,421.6***	99.3***
Partial R^2	0.2518	0.0737	0.0188	0.0118	0.0008
Robust Inference					
Anderson-Rubin (F)	2,891.4***	20.10***	1.43	0.53	0.77
Anderson-Rubin (χ^2)	40,495.5***	100.54***	5.72	1.60	1.55
confidence interval	–	–	[-0.80,3.03]	[-2.37,2.72]	[-9.11,7.56]
CLR	31,361.3***	60.07***	1.88	0.02	0.08
confidence interval	[-38.89,-37.81]	[-3.81,-2.28]	[-0.47,2.69]	[-1.83,2.16]	[-8.51,6.88]
Overidentification					
Sargan-Hansen (χ^2)	9,152.6***	40.5***	3.84	1.58	1.47
p-value	0.0000	0.0000	0.2795	0.4541	0.2250
Endogeneity					
Wu-Hausman (F)	11,000***	116.9***	114.8***	56.4***	2.68
Durbin-Wu-Hausman (χ^2)	10,100***	116.9***	114.7***	56.4***	2.68

Note. (1) All 14 potential IVs; (2) New house, dwelling to be built, unskilled trade, property postcode, and married; (3) New house, dwelling to be built, unskilled trade, and married; (4) New house, dwelling to be built, and married; (5) New house and married. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE 6.2: Mortgage Choice

	$Pr(VRM = 1)$				
	No endogeneity correction			Endogeneity correction	
	No selection	Selection bias correction			
	bias correction	2SLS	Trucation	2SLS	Truncation
$\widehat{RateSpread}$ $(r^{SFRM} - r^{VRM})$	0.144***	0.159***	0.144***	0.369***	0.277***
	[0.014]	[0.013]	[0.014]	[0.014]	[0.015]
$\widehat{Discount}$ $(r^{VRM} - r^{HM})$	-0.189***	-0.226***	-0.189***	-0.184***	-0.205***
	[0.011]	[0.010]	[0.010]	[0.010]	[0.010]
Av. VRM interest rate	-0.118***	-0.116***	-0.118***	-0.143***	-0.137***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Loan> AUD $500,000	0.176***	0.177***	0.176***	0.188***	0.179***
	[0.008]	[0.007]	[0.008]	[0.007]	[0.008]
Lowest competing SFRM rate	-0.010	-0.010	-0.010	-0.015*	-0.013*
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Unemployment rate	-0.066***	-0.063***	-0.066***	-0.131***	-0.103***
	[0.008]	[0.007]	[0.008]	[0.007]	[0.008]
House price inflation rate	-0.002*	-0.001	-0.002*	0.002*	0.000
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
%Δ Dwelling index	0.271***	0.276***	0.271***	0.328***	0.319***
	[0.010]	[0.010]	[0.010]	[0.010]	[0.011]
Net assistance FHBs	-0.002	0.000	-0.002	0.001	0.000
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Age<30 yrs. old	-0.037***	-0.033***	-0.037***	-0.039***	-0.039***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Age 30- 39 yrs. old	-0.011***	-0.011***	-0.011***	-0.015***	-0.013***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Age 50-59 yrs. old	0.015***	0.019***	0.015***	0.022***	0.020***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Age≥60 yrs. old	0.034***	0.040***	0.034***	0.048***	0.043***
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]
Female	-0.017***	-0.012***	-0.017***	-0.011***	-0.013***

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6.2 – continued from previous page

	$Pr(VRM = 1)$				
	No endogeneity correction			Endogeneity correction	
	No selection bias correction	Selection bias correction			
		2SLS	Trucation	2SLS	Truncation
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Number of dependents	-0.008***	-0.010***	-0.008***	-0.007***	-0.008***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
First-time home buyer (FHB)	0.020***	0.020***	0.020***	0.011*	0.017***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Co-borrower	-0.006*	-0.149***	-0.006*	-0.009***	-0.009***
	[0.003]	[0.008]	[0.003]	[0.003]	[0.003]
Postcode mobility	0.018***	0.020***	0.018***	0.013***	0.017***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Time at current and previous addresses	0.002***	0.002***	0.002***	0.002***	0.002***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Time at current and previous employments	-0.000	-0.000	-0.000	-0.000	-0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
log(Gross monthly income)	0.098***	0.078***	0.098***	0.032***	0.059***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Government benefits income	0.074***	0.073***	0.074***	0.065***	0.074***
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]
Rent income	0.014	0.016	0.014	0.008	0.009
	[0.030]	[0.030]	[0.030]	[0.029]	[0.030]
log(Living expenditure)	-0.014***	-0.001	-0.014***	-0.008*	-0.011**
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Professional	0.025***	0.021***	0.025***	0.017***	0.021***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Management	0.001	-0.002	0.001	-0.003	-0.002
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Skilled-trade	-0.001	0.000	-0.001	0.004	0.002
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Unskilled-trade	-0.011**	-0.007*	-0.011**	-0.002	-0.005

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6.2 – continued from previous page

	$Pr(VRM = 1)$				
	No endogeneity correction			Endogeneity correction	
	No selection	Selection bias correction			
	bias correction	2SLS	Trucation	2SLS	Truncation
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Agriculture	-0.022	-0.004	-0.022	0.010	0.003
	[0.012]	[0.012]	[0.012]	[0.012]	[0.012]
Retired	0.021	0.018	0.021	0.013	0.016
	[0.020]	[0.020]	[0.020]	[0.020]	[0.020]
Unemployed	0.051***	0.055***	0.051***	0.055***	0.056***
	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]
Small business proprietor	0.004	0.003	0.004	0.006	0.005
	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]
Self-employed	0.013***	0.013***	0.013***	0.014***	0.013***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
log(Liquid assets)	0.024***	0.024***	0.024***	0.020***	0.023***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
log(Short-term liabilities)	-0.002**	-0.002**	-0.002**	0.004***	0.005***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
log(Net wealth)	0.026***	0.025***	0.026***	0.023***	0.025***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Existing customer	-0.009**	-0.011***	-0.009**	-0.010***	-0.011***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Time with the Bank	0.004***	0.004***	0.004***	0.004***	0.004***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Number of credit accounts	0.031***	0.033***	0.031***	0.050***	0.043***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Number of credit facilities	-0.022***	-0.010***	-0.022***	-0.015***	-0.020***
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
R^2	0.0639	0.0673	0.0639	0.0698	0.0668
N	240,384	240,384	240,384	240,384	240,384

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

TABLE 6.3: LTV and Interest Rate Results

	LTV	r^k		
		VRM	$SFRM$	HM
$\widehat{\log(Val)}$	0.132			
	[1.015]			
$\widehat{LTV}$		-0.232***	-0.100***	0.058***
		[0.006]	[0.009]	[0.011]
log(Bank fees)	4.908***	0.808***	0.474***	-0.186**
	[0.439]	[0.029]	[0.047]	[0.057]
Loan term (life)	0.544***	0.119***	0.052***	-0.030***
	[0.012]	[0.003]	[0.005]	[0.006]
Lowest competing SFRM rate	-2.445***	-0.474***	-0.088***	0.184***
	[0.207]	[0.015]	[0.024]	[0.029]
Interbank rate (RBA)	-11.852***	-1.743***	0.056	1.841***
	[0.534]	[0.068]	[0.113]	[0.137]
Slope yield curve	-2.524***	-0.630***	-0.129***	0.041
	[0.168]	[0.015]	[0.024]	[0.029]
Unemployment rate	-0.926**	-0.106***	0.314***	0.078***
	[0.316]	[0.007]	[0.011]	[0.014]
House price inflation rate	0.786***	0.151***	0.018*	-0.057***
	[0.041]	[0.005]	[0.007]	[0.009]
%Δ Dwelling index	2.348***	0.621***	0.104***	-0.138***
	[0.391]	[0.015]	[0.025]	[0.030]
Net assistance FHBs	-0.495***	-0.108***	-0.050***	0.020**
	[0.084]	[0.003]	[0.005]	[0.006]
Age<30 yrs. old	4.596***	1.038***	0.453***	-0.275***
	[0.151]	[0.027]	[0.044]	[0.053]
Age 30-39 yrs. old	2.727***	0.609***	0.265***	-0.168***
	[0.108]	[0.016]	[0.026]	[0.032]
Age 50-59 yrs. old	-2.414***	-0.533***	-0.237***	0.140***
	[0.154]	[0.014]	[0.023]	[0.028]
Age≥60 yrs. old	-4.616***	-1.030***	-0.472***	0.306***
	[0.294]	[0.027]	[0.045]	[0.054]
Female	-1.277***	-0.293***	-0.136***	0.070***
	[0.102]	[0.008]	[0.012]	[0.015]
Number of dependents	-0.688***	-0.157***	-0.065***	0.041***
	[0.044]	[0.004]	[0.007]	[0.008]

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6.3 – continued from previous page

	LTV	r^k		
		VRM	$SFRM$	HM
First-time home buyer (FHB)	3.033***	0.656***	0.292***	-0.209***
	[0.230]	[0.018]	[0.030]	[0.036]
Co-borrower	2.817*	0.639***	0.272***	-0.158***
	[0.119]	[0.016]	[0.027]	[0.032]
Postcode mobility	1.170***	0.248***	0.109***	-0.092***
	[0.106]	[0.007]	[0.012]	[0.014]
Time at current and	-0.121***	-0.027***	-0.012***	0.007***
previous addresses	[0.008]	[0.001]	[0.001]	[0.001]
Time at current and	0.113***	0.025***	0.010***	-0.007***
previous employments	[0.008]	[0.001]	[0.001]	[0.001]
log(Gross monthly income)	10.454***	2.253***	1.047***	-0.543***
	[0.323]	[0.060]	[0.099]	[0.120]
Government benefits income	-4.880***	-1.1047***	-0.480***	0.271***
	[0.325]	[0.029]	[0.047]	[0.057]
Rent income	3.235**	0.768***	0.351***	-0.195***
	[1.195]	[0.027]	[0.053]	[0.054]
log(living expenditure)	-1.237***	-0.269***	-0.124***	0.051***
	[0.125]	[0.007]	[0.012]	[0.015]
Professionals	0.818***	0.161***	0.071***	-0.044***
	[0.150]	[0.005]	[0.009]	[0.011]
Management	0.635***	0.125***	0.056***	-0.024**
	[0.146]	[0.004]	[0.007]	[0.009]
Skilled-trade	-0.951***	-0.187***	-0.075***	0.053***
	[0.161]	[0.006]	[0.010]	[0.012]
Unskilled-trade	-0.329	-0.024***	-0.005	0.006
	[0.217]	[0.004]	[0.006]	[0.006]
Agriculture	0.689	0.283***	0.104***	-0.101***
	[0.611]	[0.011]	[0.014]	[0.017]
Retired	-3.871***	-0.864***	-0.346***	0.222***
	[0.820]	[0.026]	[0.044]	[0.051]
Unemployed	-3.807***	-0.846***	-0.357***	0.202***
	[0.233]	[0.022]	[0.037]	[0.044]
Small business proprietor	-0.771**	-0.168***	-0.073***	0.052***
	[0.217]	[0.006]	[0.010]	[0.011]
Self-employed	-2.043***	-0.447***	-0.199***	0.124***
	[0.163]	[0.012]	[0.020]	[0.024]
log(Liquid assets)	0.367***	0.064***	0.021***	-0.046***

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6.3 – continued from previous page

	LTV	r^k		
		VRM	$SFRM$	HM
	[0.047]	[0.002]	[0.004]	[0.004]
log(Net wealth)	-10.763***	-2.495***	-1.071***	0.651***
	[0.253]	[0.062]	[0.102]	[0.123]
Credit score	-0.038***	-0.009***	-0.003***	0.002***
	[0.000]	[0.000]	[0.000]	[0.000]
Bankruptcy flag	-5.234***	-1.235***	-0.531***	0.285***
	[1.407]	[0.039]	[0.061]	[0.077]
Default>3 yrs. flag	-4.777***	-1.073***	-0.431***	0.227***
	[0.281]	[0.028]	[0.046]	[0.055]
Existing customer	1.409***	0.316***	0.136***	-0.046**
	[0.132]	[0.008]	[0.014]	[0.017]
Time with the Bank	-0.116***	-0.026***	-0.012***	0.007***
	[0.008]	[0.001]	[0.001]	[0.001]
Number of credit accounts	1.370***	0.343***	0.092***	-0.028
	[0.071]	[0.008]	[0.013]	[0.016]
Number of credit facilities	0.139	0.047***	0.017***	0.020***
	[0.120]	[0.002]	[0.003]	[0.004]
Constant	150.370***	42.312***	13.319***	-9.792***
	[7.488]	[0.426]	[1.432]	[1.742]
Property postcode	Yes	Yes	Yes	Yes
Sigma		0.264***	0.243***	0.315***
		[0.000]	[0.001]	[0.001]
Shea Partial R^2	0.0118			
N	119,557	141,978	44,586	53,820

[standard errors]. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Chapter 7

Conclusion

The recent global financial crisis gave evidence of the misunderstanding and mis-measurement of financial risks and its impact on the real economy. Many governments and market regulators around the world have taken, or are in the process of taking, actions to reduce the vulnerability of the banking, mortgage and securitization markets. This thesis supports the argument that the focus should not only lie in systemic risk and the interactions between financial players in spreading a crisis, but also in understanding the idiosyncratic risks of financial tools, in particular, mortgage contracts.

Mortgages are complex contracts financing a good with both consumption and investment characteristics. Mortgage valuation and risk assessment is challenging in a stochastic economic environment with asymmetric information, potential moral hazard and adverse selection. The uncertainties associated with mortgages generate a series of risks for all parties involved, and mortgage design hedges some of those risks for some parties. In particular, preferences enter into valuations through differing risk attitudes. Borrowers face diverse risks when committing to a long-term mortgage; namely, income risk, wealth risk, and mobility risk. In addition, borrowers face restrictions through risk-aversion, low financial literacy, and income and wealth constraints. Each risk has a systemic and an idiosyncratic component; market risks – reflected in interest rate volatility, and changes in the inflation and unemployment rates – affect a borrower's income, wealth and mobility risk, as well as financial constraints and level of risk-aversion. The idiosyncratic component of the borrower's risk is mainly determined by the individual characteristics and circumstances of the borrower.

This thesis focused on understanding the role of borrower characteristics and individual circumstances – which reveal borrowers' preferences and risk attitudes – in the mortgage product choice and pricing. The interest lies in the idiosyncratic risk assessment implications resulted from mortgage choice, interest rate and loan-to-value ratio determination.

The overview of the Australian mortgage market contextualizes the mortgage dataset in a market where mortgage-backed securitization is still underdeveloped, there is absence of government-backed mortgage institutions, and the major mortgage originators and lenders are domestic banks who hold a large proportion of the mortgage debt on-balance sheet. We introduced the predominant owner-occupier home loan mortgage products offered in Australia: variable-rate mortgages (VRMs), short-term fixed-rate mortgages (SFRMs), discounted variable-rate or 'honeymoon' mortgages (HMs), and home equity loans (HEs).

The Australian economy, parallel to other economies in the world, experienced technological changes, greater economic and monetary stability, and financial innovation in the last twenty-five years. Deregulation increased competition and innovation in the financial sector, and the market transitioned to a lower inflation environment with lower interest rates. These developments resulted in household credit and house price growth. This scenario was impacted by the spread of the global financial crisis in 2008. Financial uncertainty led to credit tightening and a deceleration in household balance sheet accumulation. Banks faced higher funding costs, and credit growth and house price appreciation decelerated. The household sector has shifted from being net borrowers to net lenders, and the financial sector is more concentrated than it was before the financial turmoil. Australia was 'lucky' in avoiding a recession. Importantly, Australian regulators have been aware and rapidly responsive to international uncertainty and potential flaws in the financial system. New measures are being put in place to face external threats and potential internal flaws.

The rich proprietary database on over 1 million mortgage applications that was used in this thesis is a bank-originated and verified data collection recorded during the mortgage contracting process. It is of particular relevance as the originator is one of the major mortgage players in the Australian market. The dataset covers an interesting period of credit expansion in Australia, and around the world, that extended until the impact of the global financial crisis and the subsequent sovereign debt crisis in Europe – January

2003 to May 2009. This thesis reports results from the sub-sample of owner-occupier home loans (which are a good representation of the whole sample of mortgages in the dataset).

In order to abstract from the effects of the global financial crisis I concentrate the owner-occupier home loan applications made between January 2003 to August 2008.[1] This dataset enabled us to concentrate on understanding the mortgage application process at the individual loan level by exploring mortgage choice, loan-to-value ratio and interest rate determination in a period of credit expansion.

The analysis in Chapter 4 explored borrower characteristics in a non-parametric manner. We constructed borrower typologies based on borrower characteristics and the type of mortgage product contracted, applying multiple correspondence analysis (MCA) and cluster analysis. The results showed that households with high income but low wealth levels are associated to standard variable- and fixed-rate mortgages, while households with high wealth but low income levels are associated to products such as 'honeymoon' mortgages (HMs) and home equity loans (HEs).

We were able to distinguish six types of borrowers. 'Constrained (female) households' – households, where a large proportion of applicants are women in their forties, with low income and medium wealth, not mobile and with no dependents – prefer discounted variable-rate mortgages such as HMs. 'Risk averse, constrained, young families' with married borrowers in their thirties, who have children under five years old, are mobile, and have medium income and wealth levels, are more likely to choose SFRMs. 'Senior' households, with a considerable proportion of self-employed married borrowers aged fifty years old or over, who have no dependents, are not mobile, have co-borrowers and have high income and wealth levels, tend to choose HEs and VRMs. 'Mobile first-time home buyers' are mobile borrowers under thirty years old with low wealth and medium income levels, with no dependents, who decide to purchase their first home; these borrowers prefer the certainty of repayments or the early discount on repayments, and tend to choose SFRMs or HMs. 'Settled families' – married borrowers aged in their forties, relatively mobile, with children between five and fifteen years old, with medium income and wealth levels and a co-borrower – are more likely to choose VRMs, SFRMs or HMs. 'Low risk families' – married borrowers between thirty and fifty years old, with

[1] The period between September 2008 to May 2009 was excluded.

a co-borrower, high income and high wealth, and a large proportion of self-employed applicants – are mainly taking variable-rate mortgages (VRMs).

Although more than half of sampled borrowers choose VRMs, I found that borrowers that are associated with VRMs are generally less risk averse, mobile, and, most importantly, have high income and wealth levels. These results suggest that Australian borrowers bearing the interest rate risk in a VRM are in a strong financial position to face an interest rate shock.

I observed that borrowers choosing SFRMs are more risk averse and are income and/or wealth constrained, while borrowers choosing HMs are mainly only income constrained. However, I found that borrowers selecting HMs and SFRMs remain heterogeneous within mortgage product. In particular, I argued that some borrower profiles are under-served and suggested that the young 'mobile first-time home buyers' borrower profile may prefer a mortgage contract with a capped variable-rate and no early prepayment penalties. In addition, 'settled families' may prefer a long-term fixed-rate mortgage with low prepayment costs.

Borrowers who choose HEs are distinct and singular; they are mostly older, relatively less mobile, have high income but, more importantly, high wealth levels, are married and have no dependents. I suggested HEs products – which are designed to allow homeowners to smooth consumption through the equity of their property – are well matched to borrowers in the mid-point of their life-cycle.

The results in this exercise showed that HMs and SFRMs share many features and that HEs are very distinctive contracts relative to the other mortgages studied. For this reason I decided to group HMs and SFRMs as alternatives to the predominant VRM contract, and exclude home equity loans (HEs) from the subsequent analyses.

The parametric study on mortgage choice between VRMs and the alternative (HMs and SFRMs, named 'complex mortgages' or CMs[2]) predicted the conditional probability of observing a borrowers' application for a VRM, with particular focus on borrower individual characteristics as determinants of that outcome. For the first time I found evidence of multiple borrower characteristics playing a role in the mortgage product choice. I confirmed the joint significance of income, wealth and mobility constraints and

[2]CMs offer delayed repayments and attract borrowers seeking lower, and certain short-run payment commitments.

uncertainties. Risk averse borrowers facing income and wealth constraints are more likely to prefer products which reduce their initial repayments or offer repayment certainty – CMs. In contrast, those facing mobility risk and high unstable income are more likely to prefer the flexibility in a VRM. In addition, I supported the findings elsewhere that mortgage costs are the dominant determinant of product choice.

Moreover, I contributed to the literature by exploiting the effects of the LTV ratios defined by Basel capital adequacy requirements, which particularly affect lenders who retain mortgage debt on-balance-sheet.[3]

High LTV (LTV>80 percent) borrowers are more likely to seek the lowest interest rate product, relative to the benchmark applicant taking a mortgage with a LTV between 60 and 80 percent. These high LTV borrowers bear the interest rate risk of a VRM if they have high income, are self-employed (and are potentially non-risk averse and financially experienced), and have a strong mobility motive. However, high LTV borrowers are more likely to prefer the certainty in CMs if they have low, unstable income or receive income stream support from the government first-time buyer assistance scheme or from a co-borrower. In particular, low risk aversion and wealth concerns are not determinant factors in the mortgage product choice of high LTV borrowers.

Low LTV (LTV$\leq$60 percent) borrowers are less sensitive to mortgage relative costs than the benchmark applicant. They bear the interest rate risk of a VRM when they are older and wealthier. However, low LTV borrowers who are risk averse and constrained, and who maybe financially inexperienced, are more likely to take CMs. Moreover, the mobility motive is not a determinant of the mortgage product choice for low LTV borrowers.

The distinctive effects of LTV benchmarks on borrower characteristics determining mortgage choice brought me to explore possible endogeneity. I addressed both the selection bias and endogeneity problems in the specification for the probability of choosing a VRM. To the best of my knowledge, this is the first piece of research on endogeneity in mortgage product choice. I corrected for endogeneity in the LTV and interest rate determination, and corrected selection bias by estimating the mortgage interest rates specification using truncation methods. I showed that the endogeneity correction alters the effect of the

[3]Mortgages with LTV of below 80 percent (and 60 percent for low-documentation contracts) attract a 50 percent discount on Basel capital requirements.

interest rate spread between the different mortgage products. However, importantly, I found that the role of borrower characteristics is consistent across methodologies and it is significant in determining mortgage choice directly and indirectly, through LTV and interest rate determination.

Accounting for endogeneity in the mortgage choice results in a larger role for the interest rate spread between SFRMs and VRMs, and a weaker sensitivity to the discount offered in HMs.

I continued to find that borrowers who are more likely to take a VRM, relative to the benchmark borrower, are professional applicants over 50 years old, with high levels of wealth and liquid assets. I confirmed that mobile borrowers are also more likely to take a VRM. Borrowers who select away from VRM in favor of mortgage contracts with some certainty feature but higher early termination costs, such as SFRMs and HMs, are applicants under 40 years old, females, and applicants with dependents.

Interestingly, I found the bank assesses LTV based on variables that proxy for default risk of the borrower, and uses the postcode, house price inflation and expectations to asses the value of the property, but does not assess the quality of each individual property.

In addition, the initial LTV is negative and statistically significantly related to VRMs and SFRMs interest rates, suggesting that borrowers with higher LTVs pay lower interest rates in standard loans. However, the opposite result is true for HM interest rates.

I argued that the effects of macroeconomic indicators on the initial LTV have relevant policy and regulatory implications for the mortgage market. In a context where banks finance their mortgage debt mainly through domestic deposits and wholesale debt and the regulatory authority gives incentives via capital requirement discounts for low LTVs, an increase in the interbank interest rate considerably reduces the initial LTV. This result suggests a significant contraction in the supply of credit as a result of a rise in its cost. During periods of relatively high unemployment rates I observed initial lower LTVs. These considerations are important to maintain sustainable individual housing debt.

The results supported the evidence that borrowers with high credit risk, and those who tend to be more risk averse and constrained have lower initial LTVs. Mobile borrowers take mortgages with higher LTVs. However I found the strongest determinants for both mortgage initial LTVs and interest rates to be borrower income, wealth and the

interbank rate reported by the RBA. Higher monthly gross income is positively related with initial LTV (at a decreasing rate) and VRM and SFRM interest rates, while higher net wealth and liquid assets levels are associated with mortgages with lower LTVs and lower VRM and SFRM interest rates.

I also found that risk averse borrowers, and those with unstable income, take VRM or SFRM mortgages with lower interest rates than the benchmark VRM and SFRM borrower. HM borrowers who are mobile and have more stable employment pay lower HM interest rates than the benchmark HM borrower. This latter result also applied for young borrowers and first-time home buyers (FHBs) who may access lower attractive rates as new clients.

I disentangled the impact of borrower characteristics on mortgage choice into a direct effect on the mortgage product selection and an indirect effect through mortgage interest rate and loan-to-value ratio determination. This approach has improved understanding of the risk assessment and risk sharing in the mortgage market. I conclude that mortgage product design and LTV behave as non-rate terms in mortgage contracts to discriminate and account for credit and prepayment risk variability across borrowers – reflected in their personal characteristics and circumstances, or idiosyncratic risk.

Future work will explore mortgage choice, interest rate and LTV determination for a rich proprietary dataset on home loan applications originated by mortgage brokers. The contrast between factors determining mortgage product choice under brokerage or lender origination will reveal the business strategy and the customer demographics for these financial players in the mortgage market. In particular, I would expect major discrepancies for first-timer home buyers, and financially inexperienced or constrained borrowers. This agenda will complement current inquiries in the financial system and the financial services. Moreover, incorporating residential property investors to the analysis will provide a broader scope of the mortgage market and the use of financial tools available. I also intend to further explore the sub-sample of home equity loans, with particular focus on older home loan borrowers and wealth and equity management. These mortgage products are quite distinct and increasingly popular.

In addition, as part of APRA's implementation of Basel III in Australia, the RBA will introduce a committed liquidity facility (CLF) in 2015 to meet liquidity needs. The CLF will enable participating ADIs to access a pre-specified amount of liquidity

by entering into repurchase agreements of eligible securities outside the RBA's normal market operations.[4] The RBA intends to provide information about the quality of banks' balance sheets by requiring issuers of RMBS accessing the CLF to provide more detailed information on transaction-related data and on the underlying assets. This dataset will allow more precise valuation and risk assessment, providing more transparency to the Australian RMBS market.

[4]The facility, is designed to ensure that participating authorized deposit-taking institutions (ADIs) have enough access to liquidity as specified under the liquidity standard. Securities that ADIs can use under the CLF will include all securities eligible for the RBA's normal market operations – domestic issues by supranationals and other foreign governments, ADI-issued debt securities and asset-backed securities, including residential mortgage-backed securities (RMBS).

Appendix A

Variable Definitions

TABLE A.1: Definitions for Variables

Variable	Description
$RATEDIFF$ or *RateSpread*	Is the difference between the fitted rates for SFRM and VRM (may be corrected for selection bias and endogeneity). ($R^{SFRM} - R^{VRM}$)
$RATEDIFF \times$ Income	$RATEDIFF$ ($R^{SFRM} - R^{VRM}$) – as previously defined – interacted with the main applicant's real monthly gross income.
Discount	Is the difference between the the fitted interest rates for VRM and HM (may be corrected for bias selection and endogenetiy). ($R^{VRM} - R^{HM}$)
Av. VRM interest rate	Average monthly VRM interest rate reported by the bank.
Loan > AUD $500,000	Dummy for real loan amount greater than AUD $500,000.
LTV	Loan-to-value ratio (%).
log(Bank fees)	Bank fees as reported by the bank at application, in logarithm.
Loan term (life)	Length of the mortgage contract, in years.
log(Val)	Value of the property securitized under the mortgage as reported by the bank at application, in logarithm.
Interbank rate (RBA)	Monthly interbank rate reported by the RBA, F1 Interest Rates and Yields - Money Market.
Slope yield curve	Monthly yield spread between the 3-year Australian Government bond yield and the 90-day bank accepted bill yield as reported by the RBA, F1 Interest Rates and Yields - Money Market and F2 Capital Market Yields - Government Bonds.
Unemployment rate	Monthly unemployment rate reported by the ABS, Cat. No.6202.0 G7 Labour Force, unemployed persons as a percentage of labour force.
Inflation rate	Monthly inflation rate calculated from quarterly CPI reported by the ABS, Cat. No. 6401.0 G1.
House price inflation rate	Monthly housing inflation rate from ABS, Cat No 6401.0 G1.
%Δ Dwelling Index	Percentage change in the dwelling index reported by the Westpac-Melbourne Institute Survey on Consumer Sentiment. This index tracks responses on 'whether now is a good time to buy a dwelling'.

Note. Observations falling into a particular quarter are matched to the relevant quarterly data. All monetary values are expressed in 2006Q1 AUD $.

Table A.1 – continued from previous page

Variable	Description
Net assistance FHBs	Regional net government assistance for first home buyers (FHBs) of existing dwellings as a proportion of the regional median house price, from Dungey et al. [77].
Lowest competing SFRM rate	Dummy for when the fixed interest rate offered by the bank is lower than competing 3-year fixed rates offered by other lending institutions.
Age $<$ 30 yrs., Age 30-39 yrs., Age 50-59 yrs., Age $\geq$ 60 yrs.	Dummies for borrower age group. The base is a borrower between 40-49 years old.
Female	Dummy for female main borrower. The base is a male borrower.
Married	Dummy for married, or under de-facto relationship, main borrower. The base is a single borrower.
Dependent $\leq$ 5 yrs. old	Dummy for borrowers with the youngest dependent under 5 years old.
Number of dependents	Number of dependents as reported by main borrower.
First-time home buyer (FHB)	Dummy for first-time home buyer main borrower. The base is a repeat-buyer.
Co-borrower	Dummy for applications with joint borrowers.
Postcode mobility	Dummy for borrower's whose current address postcode is different to the postcode of the property under the mortgage contract.
Time at previous and current addresses	Product between the time spent in years at the current and previous addresses as reported by the main borrower at application time.
Time at previous and current employments	Product between the time spent in years at the current and previous employments as reported by the main borrower at application time.
Gross monthly income (AUD $'000s)	Gross monthly salary (for applicant and spouse), in thousands. Income from part-time and overtime work and commission, interest/-dividends, rent received, government benefits or pensions, and other monthly income.

Note. Observations falling into a particular quarter are matched to the relevant quarterly data. All monetary values are expressed in 2006Q1 AUD $.

Table A.1 – continued from previous page

Variable	Description
log(Gross monthly income)	Gross monthly salary (for applicant and spouse), in logarithm. Income from part-time and overtime work and commission, interest/-dividends, rent received, government benefits or pensions, and other monthly income.
log(Gross monthly income)^2	Quadratic term for gross monthly salary (for applicant and spouse), in logarithm.
Government benefits income	Dummy for borrowers who receive government benefits as part of their income.
Rent income	Dummy for borrowers who receive rent income as part of their income.
Living expenditure (AUD $'000s)	Monthly living expenditure, in thousands. Includes monthly personal living expenses and other expenses, in thousands. Excludes: loan, credit card, hire/purchase, rates, tax.
log(Living expenditure)	Monthly living expenditure, in logarithm. Includes monthly personal living expenses and other expenses, in thousands. Excludes: loan, credit card, hire/purchase, rates, tax.
Occupation dummies	Dummies indicating occupation categories as follows: Professional, Management, Service, Office, Skilled Trade, Unskilled trade, Agriculture, Retired, Unemployed and Small business proprietor.
Self-employed	Dummy for self-employed main borrower. The base is an employee borrower.
Liquid assets (AUD $'0000)	Stock of real liquid assets at application, in tens of thousands. Includes: revolving credit limits and amount on deposit with all financial institutions.
log(Liquid assets)	Stock of real liquid assets at application, in logarithm. Includes: revolving credit limits and amount on deposit with all financial institutions.
Net wealth (AUD $'0000)	Stock of real surplus/net wealth at application, in tens of thousands. Difference between real total assets and real total liabilities.
log(Net wealth)	Stock of real surplus/net wealth at application, in logarithm. Difference between real total assets and real total liabilities.

Note. Observations falling into a particular quarter are matched to the relevant quarterly data. All monetary values are expressed in 2006Q1 AUD $.

Table A.1 – continued from previous page

Variable	Description
Short-term liabilities (AUD $'0000)	Stock of real short-term liabilities at application, in tens of thousands. Includes: revolving credit balance outstanding with all financial institutions.
Credit score	Externally determined credit score for the applicant, scale from 0 to 1,000.
Bankruptcy flag	Dummy for a positive bankruptcy check.
Default> 3 yrs. flag	Dummy for a positive default check back-tracked for more than three years (recorded by the CRAA).
Existing customer	Dummy for applicants who are existing customers of the Bank.
Time with Bank (yrs.)	Time as a client of the bank, in years.
Number of credit accounts	Number of credit accounts held by the applicant with all financial institutions.
Number of credit facilities	Number of revolving credit facilities held by the applicant with all financial institutions.
State dummies	Regional dummies for Australian States and Territories: ACT, NSW, QLD, SA, TAS, VIC, WA.
Postcode dummies	Dummies for the postcodes of the property under the mortgage contract.

Note. Observations falling into a particular quarter are matched to the relevant quarterly data. All monetary values are expressed in 2006Q1 AUD $.

TABLE A.2: Borrower characteristic variables used in MCA.

Description	Categories
Age of the main borrower.	Age under 30 yrs. (< 30); age between 30-39 yrs. ($30 - 39$); age between 40-49 yrs. ($40 - 49$); age between 50-59 yrs. ($50 - 59$); age 60 yrs and over (≥ 60).
Main borrower income quartile.	$I1$; $I2$; $I3$; $I4$.
Main borrower net wealth quartile.	$W1$; $W2$; $W3$; $W4$.
Borrower's reported years spent at their current address.	$t < 2$ ($M1$); $2 \leq t < 4$ ($M2$); $4 \leq t < 6$ ($M3$); $6 \leq t < 8$ ($M4$); $t \geq 8$ ($M5$).
Gender of the main borrower	Male, Female.
Marital status of the main borrower	Single; Married (married or in a de-facto relationship).
Presence of dependents according to their age	No dependents (No_Dpndnt); dependents under 5 yrs. ($Dpndnt\_U5$); dependents between 5 and 15 yrs. ($Dpndnt\_O5U15$); dependents older than 15 yrs. ($Dpndnt\_O15$).
Presence of a co-borrower.	Single applicant ($Single\_App$); Co-borrower ($CoBorrwr$).
First-time home buyer	repeat buyer (non_FHBs); first-time home buyer ($FHBs$).
Employment status for the main borrower	Employee (Emp); self-employed ($Self\_Emp$).
Mortgage type	adjustable-rate mortgage (VRM); short-term fixed-rate mortgage ($SFRM$); 'honeymoon' loans (HM); home equity loans (HE).

Bibliography

[1] Ackerberg, D. A. and Botticini, M. [2002], 'Endogenous matching and the empirical determinants of contract form', *Journal of Political Economy* **110**(3), 564–591.

[2] Agarwal, S., Driscoll, J., Gabaix, X. and Laibson, D. [2009], 'The age of reason: Financial decisions over the life-cycle with implications for regulation', *Brookings Papers for Economic Activity* **Fall**, 51–117.

[3] Agarwal, S. and Qian, W. [2013], Consumption and debt response to unanticipated income shocks: Evidence from a natural experiment in Singapore, Working paper, National University of Singapore.

[4] Agnew, J. R., Anderson, L. R., Gerlach, J. R. and Szykman, L. R. [2008], 'Who chooses annuities? an experimental investigation of the role of gender, framing, and defaults', *American Economic Review* **98**(2), 418–422.

[5] Alai, D. H., Chen, H., Cho, D., Hanewald, K. and Sherris, M. [2013], Developing equity release markets: Risk analysis for reverse mortgages and home reversions, Research Paper 2013ACTL01, UNSW Australian School of Business.

[6] Allen, L. [2004], 'The Basel capital accords and international mortgage markets: A survey of the literature', *Financial Markets, Institutions and Instruments* **13**(2), 41–108.

[7] Alm, J. and Follain, J. [1984], 'Alternative mortgage instruments, the tilt problem, and consumer welfare', *Journal of Financial and Quantitative Analysis* **19**(01), 113–126.

[8] Ambrose, B. W., Buttimer, R. and Thibodeau, T. [2001], 'A new spin on the jumbo/conforming loan rate differential', *Journal of Real Estate Finance and Economics* **23**(3), 309–335.

[9] Ambrose, B. W., LaCour-Little, M. and Sanders, A. B. [2004], 'The effect of conforming loan status on mortgage yield spreads: A loan level analysis', *Real Estate Economics* **32**(4), 541–569.

[10] Amromin, G., Huang, J., Sialm, C. and Zhong, E. [2011], Complex mortgages, NBER Working Paper No.17315, National Bureau of Economic Research.

[11] Anderson, T., Rubin, H. et al. [1949], 'Estimation of the parameters of a single equation in a complete system of stochastic equations', *The Annals of Mathematical Statistics* **20**(1), 46–63.

[12] Andrews, D. W. [1999], 'Consistent moment selection procedures for generalized method of moments estimation', *Econometrica* **67**(3), 543–563.

[13] APRA [2003], Stress testing housing loan portfolios, APRA Insight Quarters 3 and 4, Australian Prudential and Regulatory Authority.

[14] APRA [2008], ADI housing lending, APRA Insight Issue 1, Australian Prudential and Regulatory Authority.

[15] APRA [2010], Stress-testing for authorised deposit-taking institutions, APRA Insight Issue 2, Australian Prudential and Regulatory Authority.

[16] ASIC [2005], Equity release products, ASIC Report 59, Australian Securities and Investment Commission.

[17] Asselin, L. and Anh, V. [2008], Multidimensional poverty and multiple correspondence analysis, *in* 'Quantitative Approaches to Multidimensional Poverty', Palgrave Macmillan, pp. 80–103.

[18] Badarinza, C., Campbell, J. Y. and Ramadorai, T. [2014], What calls to ARMs? International evidence on interest rates and the choice of adjustable-rate mortgages, Working Paper SSRN 2273430.

[19] Baesel, J. and Biger, N. [1980], 'The allocation of risk: Some implications of fixed versus index-linked mortgages', *Journal of Financial and Quantitative Analysis* **15**(2), 457–68.

[20] Baldini, N. [2010], 'University spin-offs and their environment', *Technology Analysis and Strategic Management* **22**(8), 859–876.

[21] Barber, B. M. and Odean, T. [2001], 'Boys will be boys: Gender, overconfidence, and common stock investment', *Quarterly Journal of Economics* **116**(1), 261–292.

[22] Bellante, D. and Saba, R. P. [1986], 'Human capital and life-cycle effects on risk-aversion', *Journal of Financial Research* **9**(1), 41–51.

[23] Benzécri, J. [1969], Statistical analysis as a tool to make patterns emerge from data, *in* 'Methodologies of pattern recognition', New York Academic Press, pp. 35–74.

[24] Berkovec, J., Canner, G., Gabriel, S. and Hannan, T. [1998], 'Discrimination, competition, and loan performance in FHA mortgage lending', *Review of Economics and Statistics* **80**(2), 241–250.

[25] Bernasek, A. and Shwiff, S. [2001], 'Gender, risk, and retirement', *Journal of Economic Issues* **35**(2), 345–356.

[26] Berndt, A., Hollifield, B. and Sandås, P. [2010], The role of mortgage brokers in the subprime crisis, NBER Working Paper No.16175, National Bureau of Economic Research.

[27] Boge, M. and Wilson, I. [2011], The domestic market for short-term debt securities, RBA Bulletin September Quarter, Reserve Bank of Australia.

[28] Borghans, L., Heckman, J. J., Golsteyn, B. H. and Meijers, H. [2009], 'Gender differences in risk aversion and ambiguity aversion', *Journal of the European Economic Association* **7**(2-3), 649–658.

[29] Bourassa, S. C. [1995], 'A model of housing tenure choice in Australia', *Journal of Urban Economics* **37**(2), 161–175.

[30] Bourdieu, P. [1984], *Distinction: A social critique of the judgment of taste*, Harvard University Press.

[31] Bourdieu, P. [1988], *Homo academicus*, Stanford University Press.

[32] Brown, A., Davies, M., Fabbro, D. and Hanrick, T. [2010], Recent developments in banks funding costs and lending rates, RBA Bulletin March Quarter, Reserve Bank of Australia.

[33] Brueckner, J. [1992], 'Borrower mobility, self-selection, and the relative prices of fixed- and adjustable-rate mortgages', *Journal of Financial Intermediation* **2**(4), 401–421.

[34] Brueckner, J. and Follain, J. [1988], 'The rise and fall of the ARM: An econometric analysis of mortgage choice', *Review of Economics and Statistics* **70**(1), 93–102.

[35] Brueckner, J. K. [1994], 'Borrower mobility, adverse selection, and mortgage points', *Journal of Financial Intermediation* **3**(4), 416–441.

[36] Brueckner, J. K., Calem, P. S. and Nakamura, L. I. [2013], House-price expectations, alternative mortgage products, and default, Working paper No.13-36, Federal Reserve Bank of Philadelphia.

[37] Burkhard, J. and De Giorgi, E. [2006], 'An intensity-based non-parametric default model for residential mortgage portfolios', *Journal of Risk* **8**(4), 57.

[38] Burt, C. [1950], 'The factorial analysis of qualitative data', *British Journal of Statistical Psychology* **3**(3), 166–185.

[39] Caldera Sánchez, A. and Johansson, Å. [2011], The price responsiveness of housing supply in OECD countries, OECD Economics Department Working papers No.837, Organisation for Economic Co-operation and Development.

[40] Calem, P. S. and LaCour-Little, M. [2004], 'Risk-based capital requirements for mortgage loans', *Journal of Banking and Finance* **28**(3), 647–672.

[41] Calza, A., Monacelli, T. and Stracca, L. [2013], 'Housing finance and monetary policy', *Journal of the European Economic Association* **11**(s1), 101–122.

[42] Campbell, J. Y. [2013], 'Mortgage market design', *Review of Finance* **17**(1), 1–33.

[43] Campbell, J. Y. and Cocco, J. F. [2003], 'Household risk management and optimal mortgage choice', *Quarterly Journal of Economics* **118**(4), 1449–1494.

[44] Campbell, T. S. and Dietrich, J. K. [1983], 'The determinants of default on insured conventional residential mortgage loans', *Journal of Finance* **38**(5), 1569–1581.

[45] Capone Jr, C. A. and Cunningham, D. F. [1992], 'Estimating the marginal contribution of adjustable-rate mortgage selection to termination probabilities in a nested model', *Journal of Real Estate Finance and Economics* **5**(4), 333–357.

[46] Carayol, N. [2003], 'Objectives, agreements and matching in science – industry collaborations: Reassembling the pieces of the puzzle', *Research Policy* **32**(6), 887–908.

[47] Carayol, N. and Matt, M. [2004], 'Does research organization influence academic production?: Laboratory level evidence from a large european university', *Research Policy* **33**(8), 1081–1102.

[48] Cavalluzzo, K. S. and Cavalluzzo, L. C. [1998], 'Market structure and discrimination: The case of small businesses', *Journal of Money, Credit and Banking* **30**(4), 771–792.

[49] Claessens, S., DellAriccia, G., Igan, D. and Laeven, L. [2010], 'Cross-country experiences and policy implications from the global financial crisis', *Economic Policy* **25**(62), 267–293.

[50] Cocco, J. F. [2013], 'Evidence on the benefits of alternative mortgage products', *Journal of Finance* **68**(4), 1663–1690.

[51] Coleman, A., Esho, N., Sellathurai, I. and Thavabalan, N. [2005], Stress testing housing loan portfolios: A regulatory case study, APRA Working Paper September, Australian Prudential Regulatory Authority.

[52] Connolly, E., Fleming, F. and Jääskelä, J. [2012], Households' interest-bearing assets, RBA Bulletin December Quarter, Reserve Bank of Australia.

[53] Connolly, E. and Kohler, M. [2004], The impact of superannuation on household saving, RBA Research Discussion Paper RDP2004-01, Reserve Bank of Australia.

[54] Coulibaly, B. and Li, G. [2009], 'Choice of mortgage contracts: Evidence from the survey of consumer finances', *Real Estate Economics* **37**(4), 659–673.

[55] Crowe, C., DellAriccia, G., Igan, D. and Rabanal, P. [2013], 'How to deal with real estate booms: Lessons from country experiences', *Journal of Financial Stability* **9**(3), 300–319.

[56] Cunha, M. R., Lambrecht, B. and Pawlina, G. [2013], Determinants of outstanding mortgage loan to value ratios: Evidence from the Netherlands, Working paper SSRN 1107822, EFA 2009 Bergen Meetings Paper.

[57] Cunningham, D. and Capone Jr, C. [1990], 'The relative termination experience of adjustable to fixed-rate mortgages', *Journal of Finance* **45**(5), 1687–1703.

[58] Davidoff, T. and Welke, G. [2004], Selection and moral hazard in the US reverse mortgage industry, Working Paper SSRN 608666, Haas School of Business, University of California, Berkeley.

[59] Davies, K. [2013], From where do we begin?, *in* 'Funding Australia's future', Australian Centre of Financial Studies, pp. 1–54.

[60] Davies, M. [2009], Household debt in Australia, *in* 'Household debt: implications for monetary policy and financial stability', number 46, Bank for International Settlements, pp. 19–30.

[61] Davis, K. [2011], The Australian financial system in the 2000s: Dodging the bullet, *in* 'The Australian economy in the 2000s', Reserve Bank of Australia, pp. 301–348.

[62] de Brouwer, G. [1999], 'Deregulation and open capital markets: The Australian experience before Wallis', *Agenda* **6**(1), 51–68.

[63] Deakin, J., Aitken, M., Robbins, T. and Sahakian, B. J. [2004], 'Risk taking during decision-making in normal volunteers changes with age', *Journal of the International Neuropsychological Society* **10**(04), 590–598.

[64] Deans, C. and Stewart, C. [2012], Bank's funding costs and lending rates, RBA Bulletin March Quarter, Reserve Bank of Australia.

[65] Debelle, G. [2004], Macroeconomic implications of rising household debt, BIS Working Paper No.153, Bank for International Settlements.

[66] Debelle, G. [2008], 'A comparison of the US and Australian housing markets', Assistant Governor (Financial Markets) Address to the Sub-prime Mortgage Meltdown Symposium, Adelaide, 16 May 2008.
URL: *http://www.rba.gov.au/speeches/2008/sp-ag-160508.html*

[67] Debelle, G. [2009], 'Whither securitisation?', Assistant Governor (Financial Markets) Address to the Australian Securitisation Conference, Sydney, 18 November 2009.
URL: *http://www.rba.gov.au/speeches/2009/sp-ag-181109.html*

[68] Debelle, G. [2010], 'The state of the mortgage market', Assistant Governor (Financial Markets) Address to Mortgage Innovation Conference, Sydney, 30 March 2010. **URL:** *http://www.rba.gov.au/speeches/2010/sp-ag-300310.html*

[69] DeFranco, R. [2002], Modeling residential mortgage termination and severity using loan level data, Working paper, Institute of Business and Economic Research, Fisher Center for Real Estate and Urban Economics, Univeristy of California, Berkeley.

[70] Demirgüç-Kunt, A., Kane, E. J. and Laeven, L. [2008], *Deposit Insurance around the World: Issues of Design and Implementation*, The MIT Press.

[71] Deng, Y., Quigley, J. M. and Order, R. [2000], 'Mortgage terminations, heterogeneity and the exercise of mortgage options', *Econometrica* **68**(2), 275–307.

[72] Devlin, J. F. [2002], 'An analysis of choice criteria in the home loans market', *International Journal of Bank Marketing* **20**(5), 212–226.

[73] Dhillon, U., Shilling, J. and Sirmans, C. [1987], 'Choosing between fixed and adjustable rate mortgages: Note', *Journal of Money, Credit and Banking* **19**(2), 260–267.

[74] Dhillon, U., Shilling, J. and Sirmans, C. [1990], 'The mortgage maturity decision: The choice between 15-year and 30-year frms', *Southern Economic Journal* **56**(4), 1103–1116.

[75] Donovan, B. and Gorajek, A. [2011], Developments in the structure of the Australian financial system, RBA Bulletin June Quarter, Reserve Bank of Australia.

[76] Duca, J. V., Muellbauer, J. and Murphy, A. [2011], 'House prices and credit constraints: Making sense of the US experience', *Economic Journal* **121**(552), 533–551.

[77] Dungey, M., Wells, G. and Thompson, S. [2011], 'First home buyers' support schemes in Australia', *Australian Economic Review* **44**(4), 468–479.

[78] Dunn, K. B. and McConnell, J. [1981], 'Valuation of GNMA mortgage-backed securities', *Journal of Finance* **36**(3), 599–616.

[79] Dunn, K. B. and Spatt, C. S. [1988], 'Private information and incentives: Implications for mortgage contract terms and pricing', *Journal of Real Estate Finance and Economics* **1**(1), 47–60.

[80] Dunn, K. and Spatt, C. [1985], 'An analysis of mortgage contracting: Prepayment penalties and the due-on-sale clause', *Journal of Finance* **40**(1), 293–308.

[81] Edey, M. L. and Gray, B. [1996], The evolving structure of the Australian financial system, RBA Research Discussion Paper RDP9605, Reserve Bank of Australia.

[82] Ehrmann, M. and Ziegelmeyer, M. [2013], Household risk management and actual mortgage choice in the Euro area, ECB Working Paper No.1631, European Central Bank.

[83] Ellis, L. [2006], Housing and housing finance: The view from Australia and beyond, RBA Research Discussion Paper RDP2006-12, Reserve Bank of Australia.

[84] Elsinga, M. [2011], 'A qualitative comparative approach to the role of housing equity in the life cycle', *International Journal of Housing Policy* **11**(4), 357–374.

[85] Fabbro, D. and Hack, M. [2011], The effects of funding costs and risk on banks lending rates, RBA Bulletin March Quarter, Reserve Bank of Australia.

[86] Fellenberg, K., Hauser, N., Brors, B., Neutzner, A., Hoheisel, J. and Vingron, M. [2001], 'Correspondence analysis applied to microarray data', *Proceedings of the National Academy of Sciences* **98**(19), 10781–10786.

[87] Fernández-Aguirre, K., Gallastegui-Zulaica, I., Modroño-Herrán, J. and Núñez-Antón, V. [2003], 'Clients characteristics and marketing of products: Some evidence from a financial institution', *International Journal of Bank Marketing* **21**(5), 243–254.

[88] Fortowsky, E., LaCour-Little, M., Rosenblatt, E. and Yao, V. [2011], 'Housing tenure and mortgage choice', *Journal of Real Estate Finance and Economics* **42**(2), 162–180.

[89] Fox, R. and Finlay, R. [2013], Dwelling prices and household income, RBA Bulletin December Quarter, Reserve Bank of Australia.

[90] Frame, W. and White, L. [2005], 'Fussing and fuming over Fannie and Freddie: How much smoke, how much fire?', *Journal of Economic Perspectives* **19**(2), 159–184.

[91] Fratantoni, M. C. [1999], 'Reverse mortgage choices: A theoretical and empirical analysis of the borrowing decisions of elderly homeowners', *Journal of Housing Research* **10**(2), 189–208.

[92] Fuster, A. and Vickery, J. [Forthcoming], 'Securitization and the fixed-rate mortgage', *Review of Financial Studies* .

[93] Gabriel, S. and Rosenthal, S. [Forthcoming], 'The boom, the bust, and the future of homeownership', *Real Estate Economics* .

[94] Gary-Bobo, R. J. and Larribeau, S. [2004], 'A structural econometric model of price discrimination in the French mortgage lending industry', *International Journal of Industrial Organization* **22**(1), 101–134.

[95] Gatrell, A., Popay, J. and Thomas, C. [2004], 'Mapping the determinants of health inequalities in social space: Can Bourdieu help us?', *Health and Place* **10**(3), 245–257.

[96] Geanakoplos, J. [2010], The leverage cycle, *in* 'NBER Macroeconomics Annual 2009', Vol. 24, University of Chicago Press, pp. 1–65.
URL: *http://www.nber.org/chapters/c11786*

[97] Gerardi, K., Goette, L. and Meier, S. [2010], Financial literacy and subprime mortgage delinquency: Evidence from a survey matched to administrative data, Working Paper No.2010-10, Federal Reserve Bank of Atlanta.

[98] Gizycki, M. and Lowe, P. [2000], The Australian financial system in the 1990s, *in* 'The Australian economy in the 1990s', Reserve Bank of Australia, pp. 180–215.

[99] Goggin, J., Holton, S., Kelly, J., Lydon, R. and McQuinn, K. [2012], The financial crisis and the pricing of interest rates in the Irish mortgage market: 2003-2011, Research Technical Papers 1/RT/12, Central Bank of Ireland.

[100] Green, R. and Wachter, S. [2005], 'The American mortgage in historical and international context', *Journal of Economic Perspectives* **19**(4), 93–114.

[101] Greenacre, M. [1988], 'Correspondence analysis of multivariate categorical data by weighted least-squares', *Biometrika* **75**(3), 457–467.

[102] Greenacre, M. [2007], *Correspondence Analysis in Practice*, CRC Chapman and Hall.

[103] Greenacre, M. and Hastie, T. [1987], 'The geometric interpretation of correspondence analysis', *Journal of the American Statistical Association* **82**(398), 437–447.

[104] Guttman, L. [1944], 'A basis for scaling qualitative data', *American Sociological Review* **9**(2), 139–150.

[105] Hansen, J. [2009], 'Australian house prices: A comparison of hedonic and repeat-sales measures', *Economic Record* **85**(269), 132–145.

[106] Harper, I. R. [1997], 'The Wallis report: An overview', *Australian Economic Review* **30**(3), 288–300.

[107] Haurin, D. R., Hendershott, P. H. and Wachter, S. M. [1996], Borrowing constraints and the tenure choice of young households, NBER Working Paper No.5630, National Bureau of Economic Research.

[108] Hayashi, C. [1950], 'On the quantification of qualitative data from the mathematico-statistical point of view', *Annals of the Institute of Statistical Mathematics* **2**(1), 35–47.

[109] Hendershott, P. H., LaFayette, W. C. and Haurin, D. R. [1997], 'Debt usage and mortgage choice: The FHA-conventional decision', *Journal of Urban Economics* **41**(2), 202–217.

[110] Hendershott, P. H. and Shilling, J. D. [1989], 'The impact of the agencies on conventional fixed-rate mortgage yields', *Journal of Real Estate Finance and Economics* **2**(2), 101–115.

[111] Hirschfeld, H. [1935], 'A connection between correlation and contingency', *Mathematical Proceedings of the Cambridge Philosophical Society* **31**(4), 520–524.

[112] Hoffman, D. and Franke, G. [1986], 'Correspondence analysis: Graphical representation of categorical data in marketing research', *Journal of Marketing Research* **23**(3), 213–227.

[113] Hsieh, W., Norman, D. and Orsmond, D. [2012], Supply-side issues in the housing sector, RBA Bulletin September Quarter, Reserve Bank of Australia.

[114] ICA [2003], Submission to the productivity commission on first homeownership, Issues Paper 12/308, Insurance Council Australian.

[115] IMF [2006], Australia: Financial system stability assessment, IMF Country Report No.06/372, International Monetary Fund.

[116] IMF [2012], Australia: Financial system stability assessment, IMF Country Report No.12/308, International Monetary Fund.

[117] IMF [2013], Key aspects of macroprudential policy - Background paper, IMF Report, International Monetary Fund.

[118] Jang, B. K. and Sheridan, N. [2012], Bank capital adequacy in Australia, IMF Working Paper WP/12/25, International Monetary Fund, Asia and Pacific Department.

[119] Kau, J. B. and Keenan, D. [1987], 'Taxes, points and rationality in the mortgage market', *Real Estate Economics* **15**(3), 168–184.

[120] Kau, J. B. and Keenan, D. C. [1995], 'An overview of the option-theoretic pricing of mortgages', *Journal of Housing Research* **6**(2), 217–244.

[121] Kau, J. B., Keenan, D. C. and Smurov, A. A. [2006], 'Reduced form mortgage pricing as an alternative to option-pricing models', *The Journal of Real Estate Finance and Economics* **33**(3), 183–196.

[122] Kelly, P. [2000], The politics of economic change in Australia in the 1980s and 1990s, *in* 'The Australian economy in the 1990s', Reserve Bank of Australia, pp. 222–234.

[123] Kohler, M. and Rossiter, A. [2005], Property owners in Australia: A snapshot, RBA Research Discussion Paper RDP2005-03, Reserve Bank of Australia.

[124] Kohn, J. [2011], 'What is health? a multiple correspondence health index', *Eastern Economic Journal* **38**(2), 223–250.

[125] Koijen, R., Hemert, O. and Nieuwerburgh, S. [2009], 'Mortgage timing', *Journal of Financial Economics* **93**(2), 292–324.

[126] Kulish, M., Richards, A. and Gillitzer, C. [2012], 'Urban structure and housing prices: Some evidence from Australian cities', *Economic Record* **88**(282), 303–322.

[127] La Cava, G. and Simon, J. [2003], A tale of two surveys: Household debt and financial constraints in Australia, RBA Research Discussion Paper RDP2003-08, Reserve Bank of Australia.

[128] LaCour-Little, M. and Yang, J. [2010], 'Pay me now or pay me later: Alternative mortgage products and the mortgage crisis', *Real Estate Economics* **38**(4), 687–732.

[129] Ladd, H. F. [1998], 'Evidence on discrimination in mortgage lending', *Journal of Economic Perspectives* **12**(2), 41–62.

[130] Lamont, O. and Stein, J. C. [1999], 'Leverage and house-price dynamics in US cities', *RAND Journal of Economics* **30**(3), 498–514.

[131] Landier, A., Sraer, D. and Thesmar, D. [2013], Banks' exposure to interest rate risk and the transmission of monetary policy, NBER Working Paper No.18857, National Bureau of Economic Research.

[132] Le Roux, B. and Rouanet, H. [2004], *Geometric data analysis: From correspondence analysis to structured data analysis*, Kluwer Academic Publishers.

[133] Lea, M. [2010*a*], 'Alternative forms of mortgage finance: What can we learn from other countries?', 46th Annual AREUEA Conference Paper.

[134] Lea, M. [2010*b*], International comparison of mortgage product offerings, Special Report, Research Institute for Housing America Research.

[135] Lebart, L. [1994], Complementary use of correspondence analysis and cluster analysis, *in* 'Correspondece analysis in the social sciences', Academic Press London, pp. 162–178.

[136] Lee, L. [1978], 'Unionism and wage rates: A simultaneous equations model with qualitative and limited dependent variables', *International Economic Review* **19**(2), 415–433.

[137] Lee, L. F. and Trost, R. P. [1978], 'Estimation of some limited dependent variable models with application to housing demand', *Journal of Econometrics* **8**(3), 357–382.

[138] Levy, R., Roux, P. and Wolff, S. [2009], 'An analysis of science – industry collaborative patterns in a large european university', *Journal of Technology Transfer* **34**(1), 1–23.

[139] Ling, D. and McGill, G. [1998], 'Evidence on the demand for mortgage debt by owner-occupants', *Journal of Urban Economics* **44**(3), 391–414.

[140] Loutskina, E. and Strahan, P. E. [2009], 'Securitization and the declining impact of bank finance on loan supply: Evidence from mortgage originations', *Journal of Finance* **64**(2), 861–889.

[141] Lusardi, A. [2008], Financial literacy: An essential tool for informed consumer choice?, NBER Working Paper No.14084, National Bureau of Economic Research.

[142] McKenzie, J. A. [2002], 'A reconsideration of the jumbo/non-jumbo mortgage rate differential', *Journal of Real Estate Finance and Economics* **25**(2-3), 197–213.

[143] Miles, D. [2004], 'The UK mortgage market: Taking a longer-term view', Final report and recommendations, London, HMSO.

[144] Miles, D. [2005], 'Incentives information and efficiency in the UK mortgage market', *Economic Journal* **115**(502), C82–C98.

[145] Moreira, M. J. [2003], 'A conditional likelihood ratio test for structural models', *Econometrica* **71**(4), 1027–1048.

[146] Morin, R. A. and Suarez, A. F. [1983], 'Risk aversion revisited', *Journal of Finance* **38**(4), 1201–1216.

[147] Mullet, G. [1987], 'Correspondence analysis', *Journal of Professional Services Marketing* **2**(3), 41–61.

[148] Munnell, A. H., Tootell, G. M., Browne, L. E. and McEneaney, J. [1996], 'Mortgage lending in Boston: Interpreting HMDA data', *American Economic Review* **86**(1), 25–53.

[149] Oldfield, G. S. and Santomero, A. M. [1997], The place of risk management in financial institutions, Working paper 95-05-B, The Wharton School, University of Pennsylvania.

[150] Paiella, M. and Pozzolo, A. F. [2007], Choosing between fixed and adjustable rate mortgages, Economics and Statistics Discussion Papers esdp07033, Dept. SEGeS, University of Molise.

[151] Passmore, W., Sherlund, S. M. and Burgess, G. [2005], 'The effect of housing government-sponsored enterprises on mortgage rates', *Real Estate Economics* **33**(3), 427–463.

[152] Phillips, R. A. and VanderHoff, J. [1991], 'Adjustable- versus fixed-rate mortgage choice: The role of initial rate discounts', *Journal of Real Estate Research* **6**(1), 39–52.

[153] Piskorski, T. and Tchistyi, A. [2010], 'Optimal mortgage design', *Review of Financial Studies* **23**(8), 3098–3140.

[154] Posey, L. and Yavas, A. [2001], 'Adjustable and fixed rate mortgages as a screening mechanism for default risk', *Journal of Urban Economics* **49**(1), 54–79.

[155] Qi, M. and Yang, X. [2009], 'Loss given default of high loan-to-value residential mortgages', *Journal of Banking and Finance* **33**(5), 788–799.

[156] Quercia, R. G. and Stegman, M. A. [1992], 'Residential mortgage default: A review of the literature', *Journal of Housing Research* **3**(2), 341–379.

[157] Riley Jr, W. B. and Chow, K. V. [1992], 'Asset allocation and individual risk aversion', *Financial Analysts Journal* **48**(6), 32–37.

[158] Robertson, B. and Rush, A. [2013], Developments in banks funding costs and lending rates, RBA Bulletin March Quarter, Reserve Bank of Australia.

[159] Rosenthal, S. S. and Zorn, P. [1993], 'Household mobility, asymmetric information, and the pricing of mortgage contract rates', *Journal of Urban Economics* **33**(2), 235–253.

[160] Rouanet, H., Ackermann, W. and Le Roux, B. [2000], 'The geometric analysis of questionnaires: The lesson of Bourdieu's La Distinction', *Bulletin de Méthodologie Sociologique* **65**(1), 5–18.

[161] Rudd, S. and Stewart, C. [2012], Banking fees in Australia, RBA Bulletin June Quarter, Reserve Bank of Australia.

[162] Sa-Aadu, J. and Sirmans, C. [1995], 'Differentiated contracts, heterogeneous borrowers, and the mortgage choice decision', *Journal of Money, Credit and Banking* **27**(2), 498–510.

[163] Santomero, A. M. [1983], 'Fixed versus variable rate loans', *Journal of Finance* **38**(5), 1363–1380.

[164] Sapienza, P., Zingales, L. and Maestripieri, D. [2009], 'Gender differences in financial risk aversion and career choices are affected by testosterone', *Proceedings of the National Academy of Sciences* **106**(36), 15268–15273.

[165] Sargan, J. D. [1958], 'The estimation of economic relationships using instrumental variables', *Econometrica* **26**(3), 393–415.

[166] Scanlon, K., Lunde, J. and Whitehead, C. [2008], 'Mortgage product innovation in advanced economies: More choice, more risk', *European Journal of Housing Policy* **8**(2), 109–131.

[167] Schafer, R. and Ladd, H. F. [1981], *Discrimination in mortgage lending*, MIT Press Cambridge, MA.

[168] Schubert, R. [1999], 'Financial decision-making: Are women really more risk-averse?', *American Economic Review* **89**(2), 381–385.

[169] Schwartz, C. [2010], The Australian government guarantee scheme, RBA Bulletin March Quarter, Reserve Bank of Australia.

[170] Shea, J. [1997], 'Instrument relevance in multivariate linear models: A simple measure', *Review of Economics and Statistics* **79**(2), 348–352.

[171] Shiller, R. J. and Weiss, A. N. [2000], 'Moral hazard in home equity conversion', *Real Estate Economics* **28**(1), 1–31.

[172] Spearman, C. [1904], '"General intelligence", objectively determined and measured', *American Journal of Psychology* **15**(2), 201–292.

[173] Spiegel, M. and Strange, W. [1992], 'A theory of predictable excess returns in real estate', *Journal of Real Estate Finance and Economics* **5**(4), 375–392.

[174] Stanton, R. and Wallace, N. [1998], 'Mortgage choice: What's the point?', *Real Estate Economics* **26**(2), 173–205.

[175] Statman, M. [1982], 'Fixed rate or index-linked mortgages from the borrower's point of view: A note', *Journal of Financial and Quantitative Analysis* **17**(3), 451–457.

[176] Stewart, C., Robertson, B. and Heath, A. [2013], Trends in the funding and lending behaviour of Australian banks, RBA Discussion Paper RDP2013-15, Reserve Bank of Australia.

[177] Stock, J. H., Wright, J. H. and Yogo, M. [2002], 'A survey of weak instruments and weak identification in generalized method of moments', *Journal of Business and Economic Statistics* **20**(4).

[178] Stock, J. H. and Yogo, M. [2005], 'Testing for weak instruments in linear IV regression', Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg.

[179] Swan, W. and Tanner, L. [2009], 'Updated economic and fiscal outlook February 2009', Budget, Treasury, Commonwealth of Australia, Canberra.

[180] Szerb, L. [1996], 'The borrower's choice of fixed and adjustable rate mortgages in the presence of nominal and real shocks', *Real Estate Economics* **24**(1), 43–54.

[181] Tenenhaus, M. and Young, F. [1985], 'An analysis and synthesis of multiple correspondence analysis, optimal scaling, dual scaling, homogeneity analysis and other methods for quantifying categorical multivariate data', *Psychometrika* **50**(1), 91–119.

[182] Vandell, K. D. [1978], 'Default risk under alternative mortgage instruments', *Journal of Finance* **33**(5), 1279–1296.

[183] Vickery, J. [2007], Interest rates and consumer choice in the residential mortgage market, Proceedings No.1076, Federal Reserve Bank of New York.

[184] Von Furstenberg, G. M. [1969], 'Default risk on FHA-insured home mortgages as a function of the terms of financing: A quantitative analysis', *Journal of Finance* **24**(3), 459–477.

[185] Warnock, V. C. and Warnock, F. E. [2008], 'Markets and housing finance', *Journal of Housing Economics* **17**(3), 239–251.

[186] Watson, J. and McNaughton, M. [2007], 'Gender differences in risk aversion and expected retirement benefits', *Financial Analysts Journal* **63**(4), 52–62.

[187] Wong, E., Fong, T., Li, K.-f. and Choi, H. [2011], Loan-to-value ratio as a macro-prudential tool: Hong Kong's experience and cross-country evidence, Working Paper 01/2011, Research Department, Hong Kong Monetary Authority.

[188] Wood, G., Watson, R. and Flatau, P. [2003], A microsimulation model of the Australian housing market with applications to Commonwealth and state policy initiatives, AHURI Final Report No.33, Australian Housing and Urban Research Institute.

[189] Yamashita, T. [2007], 'House price appreciation, liquidity constraints, and second mortgages', *Journal of Urban Economics* **62**(3), 424–440.

[190] Yang, T. [1992], 'Self-selection in the fixed-rate mortgage market', *Real Estate Economics* **20**(3), 359–391.

[191] Yates, J. [2011], Housing in Australia in the 2000s: On the agenda too late?, *in* 'The Australian economy in the 2000s', Reserve Bank of Australia, pp. 261–296.

[192] Yates, J. [2014], 'Protecting housing and mortgage markets in time of crisis: A view from Australia', *Journal of Housing and the Built Environment* **29**(2), 361–382.

[193] Yezer, A. M., Phillips, R. F. and Trost, R. P. [1994], 'Bias in estimates of discrimination and default in mortgage lending: The effects of simultaneity and self-selection', *Journal of Real Estate Finance and Economics* **9**(3), 197–215.

[194] Zorn, P. M. and Lea, M. J. [1989], 'Mortgage borrower repayment behavior: A microeconomic analysis with Canadian adjustable rate mortgage data', *Real Estate Economics* **17**(1), 118–136.